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Date: August 21, 2009 Name: Tadashi Horie, Reg. No. 40,437 Signature: Tadashi H

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of:	Satoru ADACHI et al.	
Appln. No.:	12/191,563	Examiner: Patel, Jayesh A.
Filed:	August 14, 2008	Art Unit: 2624
For:	IMAGE ENCODING METHOD, IMAGE DECODING METHOD, IMAGE ENCODING APPARATUS, IMAGE DECODING APPARATUS, IMAGE ENCODING PROGRAM, AND IMAGE DECODING PROGRAM	Confirmation No.: 1071
Attorney Docket No:	9683/293	

DECLARATION UNDER 37 CFR 1.131

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION

We, the undersigned, hereby declare that

1. We are the inventors of the invention disclosed and claimed in the United States Patent Application having serial number 12/191,563, filed August 14, 2008 ("the '563 application").

2. The '563 application is a continuation application of the United States Patent Application having serial number 10/680,205 filed October 8, 2003 ("the '205 application"), which claims priority to Japanese Patent Application No. JP 2002-295,429 filed in Japan on October 8, 2002.

3. Exhibit A is a printout of an e-mail prepared by Mr. Satoru Adachi, one of the inventors of the '205 application, and sent to Mr. Thiow Keng Tan, another inventor of the '205 application. Although the date of the e-mail is redacted in Exhibit A, the e-mail was prepared and sent prior to October 3, 2002, the effective date of U.S. Patent Application Publication No. 2004-0066974 (Karczewicz et al.).

4. Exhibit A reported the results of simulations conducted regarding the performance of our invention and evaluations of the simulation results made by Mr. Adachi. As described in Exhibit A, the simulations were conducted to implement "CAVLC on ABT", using three different methodologies, "Split," "Real" and "Interleave." The purpose of the simulations was to determine a methodology which could exhibit the best performance among the three in implementing CAVLC on ABT.

5. In "Split," transform coefficients in a block having a size of, for example, 8x8 are zig-zag scanned and arranged into a string of 64 coefficients (one dimensional), and then the string is divided at equal intervals into four strings, each having 16 coefficients.

6. In "Real," an 8x8 block having 64 transform coefficients is divided into four quadrants, each being a 4x4 sub-block, and the transform coefficients in each sub-block is zig-zag scanned and arranged into a string of 16 coefficients, yielding four strings each having 16 coefficients.

7. In "interleave," which is our invention, 64 transform coefficients in an 8x8 block are zig-zag scanned and interleaved into four strings each having 16 transform coefficients.

8. We prepared simulation programs for the respective three methodologies and run the programs to implement CALVC on ABT on the three methodologies. Exhibit B is a printout of a part of the results of the simulations from "CAVLC performance on ABT coeff split.xls" mentioned in Exhibit A.

9. In Exhibit B, prior art is identified as "JM4.0d." The graphs in Exhibit B showed the performances (%) of the three methodologies improved over JM4.0dAs in relation to various compression levels (12, 16, 20, 24, 28, 32, 36, 40). Thus, a methodology which exhibited higher performance in the simulations manifested itself higher in the graphs. It was our observation that the overall simulation results favored our invention "Interleave" most among the three methodologies.

10. Exhibit C is an excerpt from the simulation program to implement our invention, "Interleave," in the encoding process. Exhibit D is an excerpt from the simulation program to implement our invention in the decoding process.

11. In Exhibit A, Mr. Adachi indicated that he had not yet implemented a decoder. He meant that he had not run a simulation program for a decoder as of the date of Exhibit A. However, as of the date of Exhibit A, he had confirmed the performance of our invention in the decoding process during the simulations for an encoder because an encoder necessarily implements the decoding process.

12. Encouraged by the simulation results, we decided to propose our invention to Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG and file a patent application for the invention. Exhibit E is an e-mail prepared and sent to spg-visual by Mr. Adachi subsequent to the simulations, yet still prior to October 3, 2002. "spg-visual" was a representative mail address of the visual team in the signal processing group, to which Mr. Adachi belonged. The team leader of the visual team was then Mr. Minoru Etoh, another inventor of our invention. The team also included Mr. Sadaatsu Kato, another inventor of our invention. Our invention is noted in Exhibit E as "A method for applying context-adaptive variable-length coding to adaptive orthogonal transform size image encoding."

13. In Exhibit E, Mr. Adachi indicated that he would complete drafting of a patent application for our invention as soon as he could. As promised, Mr. Adachi worked on drafting the patent application every day from the date of Exhibit E through October 8, 2002, including the days from October 3, 2002 through October 8, 2002.

14. Mr. Adachi knew that he had to file the patent application no later than October 8, 2002 and that very little time would be given to Japanese counsel to perfect his draft application before the filing thereof in the Japanese Patent Office. Therefore, Mr. Adachi spent a significant amount of time every day to try to prepare as perfect and comprehensive a draft application as possible so that Japanese counsel would need little time to prepare a formal patent application from his draft application.

15. A byproduct of Mr. Adachi's efforts in preparing a draft application was a proposal to Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG. Exhibit F is the proposal to JVT prepared by Mr. Adachi and uploaded on a server of JVT on October 5, 2002 for discussion at a meeting held in Switzerland on October 9-17, 2002. Exhibit F described our invention and we believe serves an indication of how much Mr. Adachi's draft application was completed as of October 5, 2002.

16. It took Mr. Adachi three more days to complete his draft application after the proposal to JVT was uploaded. Exhibit G is the draft patent application prepared by Mr. Adachi which was completed on October 8, 2002 and sent to the Japanese counsel on the same day.

17. Exhibit H is copies of the drawings prepared by Mr. Adachi which were completed on October 8, 2002 for his draft application.

18. The Japanese counsel prepared a formal patent application from Mr. Adachi's draft application and filed it in the Japanese Patent Office on October 8, 2002, which was later assigned Serial Number JP 2002-295,429.

We hereby declare that all statements made herein are of our own knowledge and are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the Unites States code, and that such willful

statements may jeopardize the validity of the application or any patent issued therefrom.

Respectfully submitted,

Satoru Adachi	July 1, 2009.
Satoru Adachi	Date
Minoru Etoh	July 1st, 2009
Minoru Etoh	Date
Sadaatsu Kato	July 3rd. 2009.
Sadaatsu Kato	Date
Thiow Keng Tan	July 10, 2009
Thiow Keng Tan	Date

Exhibit A

> Date: [redacted]
> To: <tktan>
> From: ADACHI Satoru <adachi>
> Subject: RE: FW: [jvt_vlc_adhoc] CAVLC for ABT
>
> Dear TK,
>
> Attached please find data for CAVLC on ABT.
>
> >> CAVLC_ABT_addCIF[redacted].xls:
>
> Results of your implementation. I added, to your data, my results of CIF
> sequences, tempete, bus, flowergarden in addition to mobile, paris. Data
> of "JM4.0d" and "CAVLC all blk sz" is simply copied from Real's results,
> as I did for mobile and paris.
>
> I also add my additional CIF results on your latest Excel file you just
> sent me. The revised one is jm40c_abt2_adachi_ttk_addCIF_[redacted].xls.
>
> >> CAVLC performance on ABT coeff split [redacted].xls:
>
> Comparison of our implementation. We implemented "real" (division as Real
> did, but it implemented ourselves), "split", and "interleave". We
> introduced simple reordering and division of ABT coefficients, and not
> introduce new table selection nor CBP.
>
> Please compare "CAVLC_ABT_addCIF[redacted].xls" and "CAVLC performance on
ABT
> coeff split [redacted].xls" each other. You can see that our "real" results
> and "CAVLC all BLK sz", and, our "split" results and your "abt scan split
> + NTS", have the same tendency respectively. I think it shows correctness
> of our implementation to some extent. (To tell the truth, we did not
> implement decoder yet! We will do it ASAP!)
>
> Although we need to carefully check the correctness of our
> implementation, from the results, I think we can see some interesting findings.
>
> 1. Real's approach does provide good improvement with no modification on
> current CAVLC.
>
> 2. "split" does not work better than Real's. The possible gain provided
> by new table selection seems not to recover this inefficiency.
>
> 3. "interleave" works best among the three approach, on both Intra and Inter.

>
> I was surprised that "split" did not work better, and Real's and
> "interleave" works good even though they break the original correlation
> on the scan thus we assumed they are less efficient.
>
> I think, one of the reason on this is as follows; Distribution of the
> coefficients on the scanned sequence of coefficients does have a property
> of (simply) concentrating at low frequency, but is relatively random on
> each part of the sequence. Each part of the sequence just have the same
> tendency of distribution, but does not have special dependency on, for
> example, frequency band of that part. Thus a way of extraction
> coefficients, from the sequence of coefficients does not bather (i.e.,
> does not make ineffective) the CAVLC design. Rather, "split" provides
> unusual concentration/depopulation of the coefficients and bather the
> CAVLC design.
>
> If this is the case, "interleave" should be the best approach to
> introduce CAVLC on ABT. It can apply to interlace scan ("field scan") and
> it should work good on the scan. Since it does not divide the
> coefficients into low/high frequency quadrant, the divided blocks of
> coefficients would not have particular correlation, thus N (NumCoeff
> prediction) should equally work well on each block without special rule
for ABT.
>
> I think we can patent this. A question I have is; should we refer to
> Real's approach as an prior art?
>
> Please comment and give us another point of view.
>
> Thanks and best regards,
> Satoru Adachi

Exhibit B

JM4.0d
ALL

			Intra	
12	48.57	540.48	49.84	103656
16	45.45	353.55	46.69	74600
20	42.17	222.78	43.18	50504
24	39.1	137.64	40.04	33912
28	36.33	83.21	37.28	22768
32	33.64	51.35	34.51	15152
36	31.08	31.79	31.85	9872
40	28.55	20.01	29.40	6472

split
all

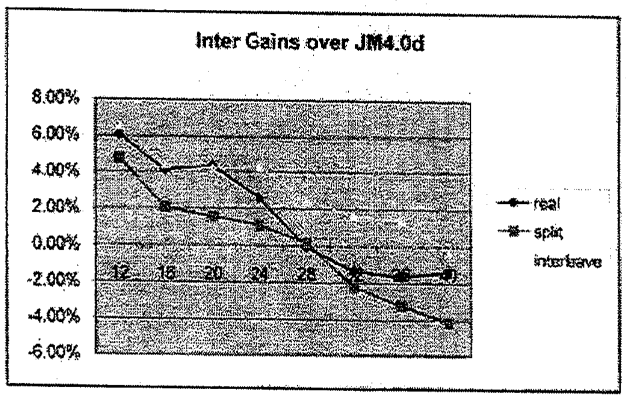
		Intra			
48.7	514.84	50.0543	84256	4.74%	18.24%
45.57	346.21	46.7714	64400	2.08%	14.21%
42.25	219.33	43.2226	45416	1.55%	10.07%
39.2	136.12	40.1	31360	1.10%	7.53%
36.4	83.1	37.2624	21544	0.13%	5.38%
33.72	52.5	34.5087	14480	-2.24%	4.44%
31.[illegible]	32.83	31.8193	9512	-3.27%	3.65%
28.57	20.85	29.3479	6504	-4.20%	-0.49%

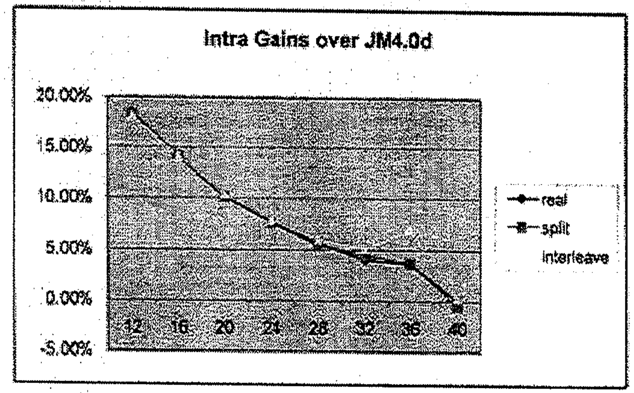
real
ALL

		Intra			
48.71	507.89	50.094	84072	6.03%	18.42%
45.55	338.96	46.7809	64048	4.13%	14.14%
42.26	213.02	43.2107	45392	4.38%	10.12%
39.21	134.08	40.0566	31304	2.59%	7.69%
36.43	83.26	37.262	21472	-0.06%	5.69%
33.73	52.05	34.4704	14544	-1.36%	4.01%
31.1	32.32	31.8671	9512	-1.67%	3.65%
28.55	20.29	29.2981	6472	-1.40%	0.00%

interleave
all

		Intra			
48.69	504.97	50.0583	84400	6.57%	18.10%
45.55	337.84	46.7673	64032	4.44%	14.17%
42.27	213.27	43.2419	45264	4.27%	10.38%
39.23	131.66	40.0453	31256	4.34%	7.83%
36.43	81.1	37.2612	21392	2.54%	6.04%
33.74	50.49	34.5455	14368	1.67%	5.17%
31.17	31.34	31.8256	9168	1.42%	7.13%
28.61	20.06	29.4715	6456	-0.25%	0.25%





JM4.0d

ALL

			Intra	
12	48.48	332.95	49.90	117680
16	45.32	206.08	46.66	88256
20	41.89	110.49	43.15	59584
24	38.85	57.28	39.88	40448
28	36.13	29.38	37.18	27896
32	33.46	16.02	34.32	18880
36	30.72	9.2	31.43	12408
40	28.01	5.11	28.70	8320

split

all

		Intra			
48.51	325.36	50.0868	88976	2.28%	24.39%
45.4	201.78	46.8499	68424	2.09%	20.67%
42.03	109.09	43.2732	49872	1.27%	16.30%
38.98	56.78	40.0417	35712	0.67%	11.71%
36.27	28.67	37.2497	25520	2.42%	8.52%
33.51	15.37	34.3936	17632	4.06%	5.55%
30.81	8.82	31.4915	11792	4.13%	4.96%
28.01	5.09	28.6288	8056	0.39%	3.17%

real

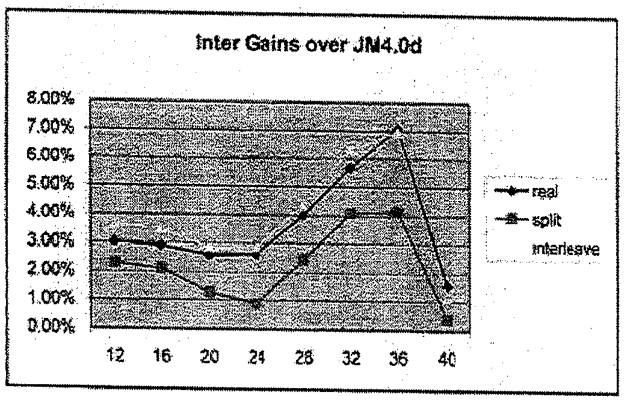
ALL

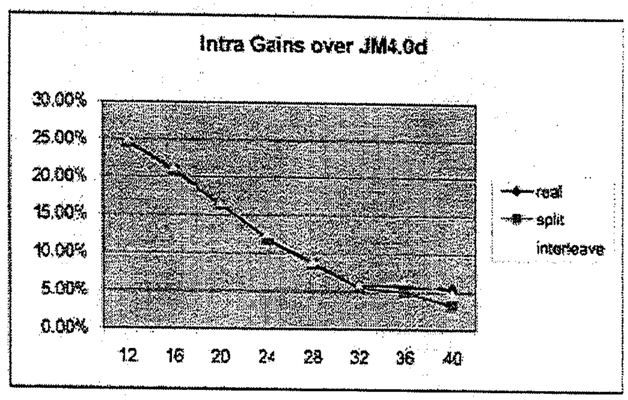
		Intra			
48.53	322.86	50.0768	88688	3.03%	24.64%
45.42	200.13	46.8241	67928	2.89%	21.25%
42.08	107.66	43.227	49800	2.56%	16.42%
39	55.79	40.1016	35704	2.60%	11.73%
36.23	28.21	37.1676	25400	3.98%	8.95%
33.51	15.11	34.32	17752	5.68%	5.97%
30.85	8.55	31.4671	11704	7.07%	5.67%
28.01	5.03	28.5712	7872	1.57%	5.38%

interleave

all

		Intra			
48.53	320.77	50.0503	88352	3.66%	24.92%
45.43	198.35	46.821	67864	3.51%	21.32%
42.07	107.34	43.2594	49720	2.85%	16.55%
39.03	55.64	40.0151	35360	2.86%	12.58%
36.24	28.1	37.1366	25376	4.36%	9.03%
33.52	15	34.3484	17752	6.37%	5.97%
30.82	8.56	31.4601	11600	6.96%	6.51%
28.1	5.35	28.7391	7920	1.17%	4.81%



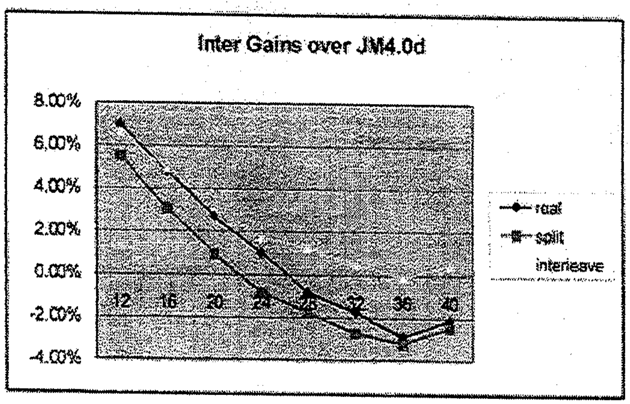


JM4.0d

	ALL		Intra	
12	48.5	391.79	49.74	124848
16	45.53	257.36	46.52	91288
20	42.25	164.97	42.86	63800
24	39.04	104.34	39.46	43208
28	35.97	65.15	36.36	28248
32	33.12	39.78	33.47	18024
36	30.62	23.22	30.93	10776
40	28.15	13.47	28.56	6840

split

all		Intra			
48.69	370.33	50.1866	103432	5.48%	17.15%
45.72	249.58	46.6806	80208	3.02%	12.14%
42.41	162.53	42.9989	58408	0.94%	8.45%
39.1	105.23	39.461	40696	-0.85%	5.81%
36.04	66.32	36.3486	27120	-1.80%	3.95%
33.19	40.37	33.5433	17352	-2.74%	3.73%
30.52	23.97	30.8789	10656	-3.23%	1.11%
28.08	13.8	28.467	6728	-2.45%	1.64%

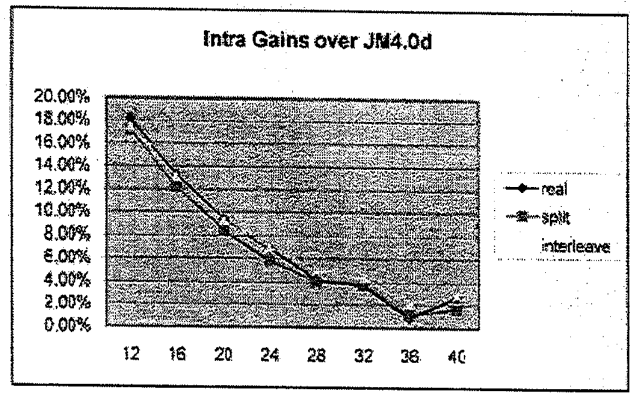


real

ALL		Intra			
48.69	364.43	50.1008	102168	6.98%	18.17%
45.68	245	46.6645	79160	4.80%	13.29%
42.38	159.64	42.9492	57816	2.70%	9.38%
39.1	103.26	39.4746	40224	1.04%	6.91%
36.1	65.68	36.388	27072	-0.61%	4.16%
33.13	40.47	33.4513	17360	-1.73%	3.68%
30.59	23.89	30.8531	10680	-2.89%	0.89%
28.11	13.75	28.4857	6656	-2.08%	2.69%

interleave

all		Intra			
48.68	365.9	50.1507	103104	5.61%	17.42%
45.69	244.7	46.6028	79312	4.92%	13.12%
42.39	158.95	42.9456	57680	3.12%	9.28%
39.11	102.5	39.4745	40168	1.76%	7.04%
36.09	64.3	36.4288	26824	1.30%	5.04%
33.21	39.57	33.5376	17232	0.53%	4.39%
30.58	23.24	30.8995	10536	-0.09%	2.23%
28.17	13.4	28.4696	6640	0.52%	2.92%



JM4.0d

ALL			Intra	
12	48.78	278.65	50.07	115768
16	46.03	189.24	47.09	85680
20	43.04	123.97	43.75	61792
24	39.99	80.57	40.45	44136
28	36.99	51.13	37.40	31048
32	33.93	31.54	34.37	21192
36	31.02	19.14	31.29	14096
40	28.22	11.62	28.62	9512

split

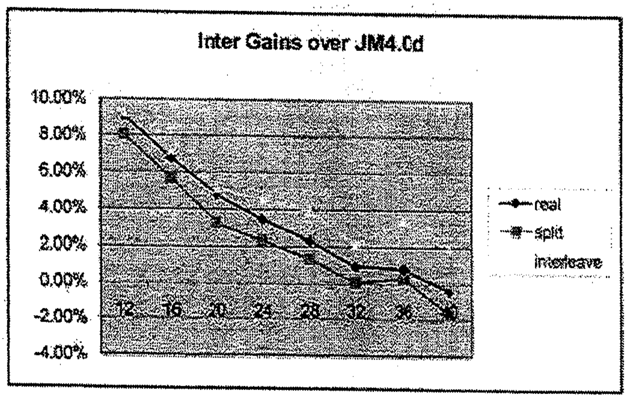
all		Intra			
48.9	256.2	50.3454	87424	8.06%	24.48%
46.16	178.52	47.3224	67688	5.66%	21.00%
43.13	119.97	43.8438	51592	3.23%	16.51%
40.06	78.74	40.6709	38648	2.27%	12.43%
37.07	50.46	37.6264	27960	1.31%	9.95%
34.02	31.53	34.4165	19848	0.03%	6.34%
31.04	19.09	31.3345	13576	0.26%	3.69%
28.27	11.82	28.6148	9376	-1.72%	1.43%

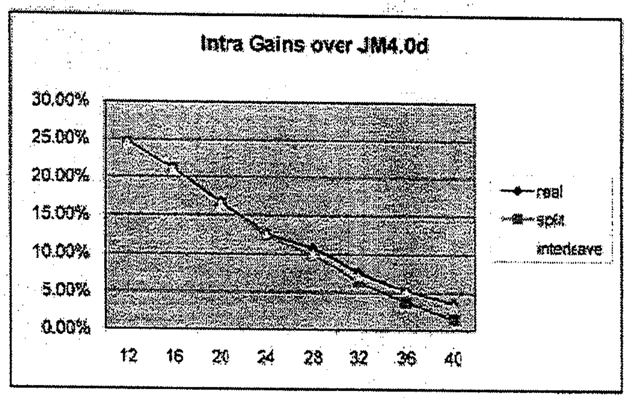
real

ALL		Intra			
48.93	253.26	50.3426	87248	9.11%	24.64%
46.16	176.43	47.3415	67624	6.77%	21.07%
43.13	118.05	43.9114	51432	4.78%	16.77%
40.03	77.81	40.6615	38560	3.43%	12.63%
37.08	49.96	37.5458	27680	2.29%	10.85%
34.04	31.25	34.3268	19576	0.92%	7.63%
31.12	18.99	31.2922	13376	0.78%	5.11%
28.28	11.67	28.6727	9176	-0.43%	3.53%

interleave

all		Intra			
48.92	252.79	50.3411	87488	9.28%	24.43%
46.14	175.62	47.2997	67720	7.20%	20.96%
43.13	117.57	43.9449	51640	5.16%	16.43%
40.1	76.88	40.6219	38528	4.58%	12.71%
37.11	49.12	37.5765	27928	3.93%	10.05%
34.05	30.86	34.4568	19688	2.16%	7.10%
31.17	18.48	31.4297	13384	3.45%	5.05%
28.33	11.38	28.6569	9200	2.07%	3.28%





JM4.0d

ALL		Intra		
12	47.91	11289.29	49.70	828088
16	44.6	7858.17	46.30	635104
20	41.04	5194.96	42.59	464920
24	37.53	3316.61	38.83	333672
28	34.1	1977.26	35.47	241632
32	30.61	1038.93	31.95	170160
36	27.42	487.87	28.65	114800
40	24.56	232.03	25.63	75712

split

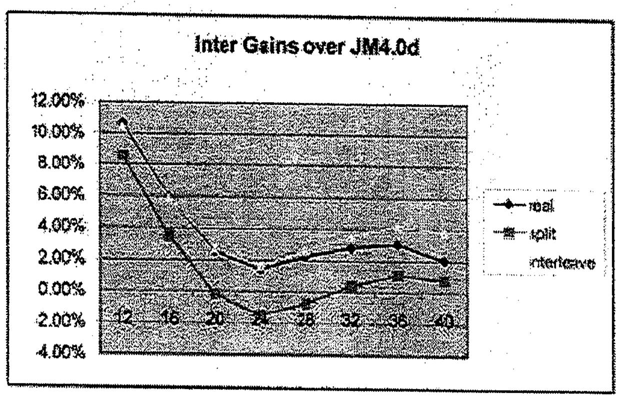
all		Intra			
47.99	10324.67	50.1049	579112	8.54%	30.07%
44.66	7584.66	46.6524	475000	3.48%	25.21%
41.08	5203.35	42.8148	378232	-0.16%	19.08%
37.59	3366.19	39.0872	291848	-1.49%	12.53%
34.19	1992.25	35.5759	220160	-0.76%	8.89%
30.77	1034.79	31.9809	160352	0.40%	5.76%
27.59	482.54	28.6229	109648	1.09%	4.49%
24.65	230.3	25.6243	73368	0.75%	3.10%

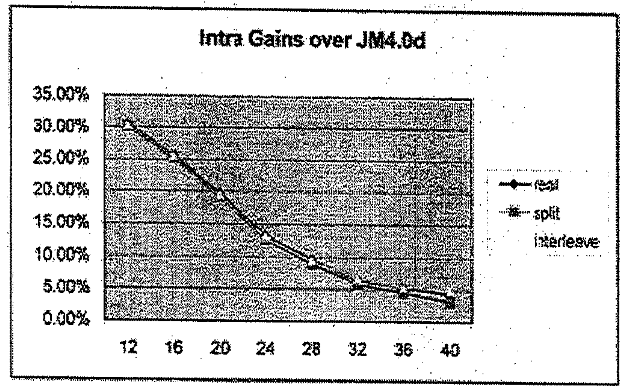
real

ALL		Intra			
47.99	10089.93	50.0672	576480	10.62%	30.38%
44.65	7391.91	46.6537	472592	5.93%	25.59%
41.07	5060.83	42.7896	373608	2.58%	19.64%
37.6	3269.16	39.0843	289480	1.43%	13.24%
34.23	1932.57	35.5914	218432	2.26%	9.60%
30.83	1009.7	32.0002	159104	2.81%	6.50%
27.67	472.97	28.6757	108624	3.05%	5.38%
24.71	227.27	25.6338	72432	2.05%	4.33%

interleave

all		Intra			
47.99	10112.25	50.0412	576992	10.43%	30.32%
44.65	7394.76	46.6156	473000	5.90%	25.52%
41.07	5052.94	42.799	374592	2.73%	19.43%
37.6	3261.49	39.0748	289896	1.66%	13.12%
34.21	1925.07	35.5699	218792	2.64%	9.45%
30.83	1001.75	32.0251	158792	3.58%	6.68%
27.68	467.32	28.7137	108592	4.21%	5.41%
24.76	223.09	25.6457	71952	3.85%	4.97%





JM4.0d

ALL		Intra		
12	47.97	2586.51	49.64	583720
16	44.74	1444.84	46.42	429184
20	41.73	880.88	43.01	305784
24	38.71	552.64	39.67	215360
28	35.7	352.57	36.57	152268
32	32.62	214.01	33.44	105008
36	29.77	123.53	30.42	70352
40	26.93	68.48	27.50	46392

split

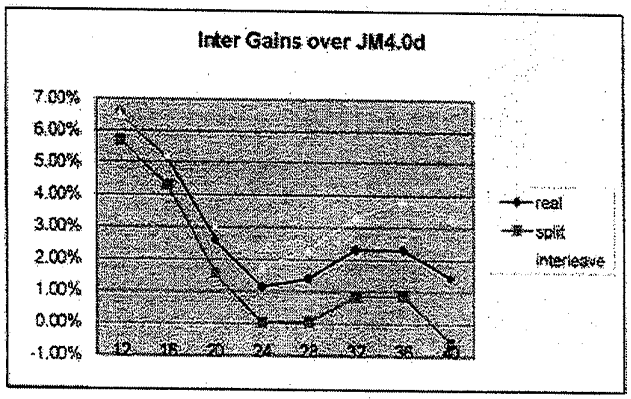
all	Intra				
48.16	2439.16	49.8948	434520	5.70%	25.56%
44.3	1382.75	46.6176	336832	4.30%	21.52%
41.83	847.44	43.1541	255128	1.56%	16.57%
38.82	552.6	39.8628	189944	0.01%	11.80%
35.73	352.42	36.6683	138952	0.04%	5.76%
32.7	212.33	33.4512	96240	0.83%	6.45%
29.85	122.47	30.4777	66616	0.86%	5.31%
27.03	68.89	27.5581	44704	-0.60%	3.64%

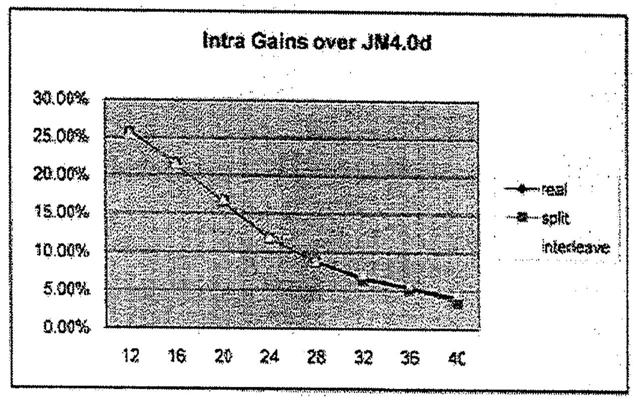
real

ALL	Intra				
48.16	2417.11	49.9032	433704	6.55%	25.70%
44.9	1370.11	46.6043	336432	5.17%	21.61%
41.89	838.34	43.1331	254256	2.62%	16.85%
38.84	546.3	39.8186	189552	1.15%	11.98%
35.81	347.6	36.6885	138712	1.41%	8.91%
32.72	209.03	33.4937	97984	2.33%	6.69%
29.83	120.67	30.4881	66536	2.32%	5.42%
27.03	67.49	27.5462	44464	1.45%	4.16%

interleave

all	Intra				
48.15	2417.33	49.89	434544	6.54%	25.56%
44.91	1368.94	46.6114	335568	5.25%	21.58%
41.9	834.39	43.1069	254256	3.08%	16.85%
38.85	542.84	39.8363	189432	1.77%	12.04%
35.8	344.36	36.6694	139656	2.33%	8.95%
32.76	206.9	33.46	97416	3.32%	7.23%
29.86	118.75	30.4567	66168	3.87%	5.95%
27.04	66.16	27.568	44224	3.39%	4.67%





JM4.0d

ALL			Intra			
12	48.12	9709.78	49.64	660920		
16	44.54	6518.18	46.29	485400		
20	41.56	4144.35	42.64	341992		
24	38.23	2560.57	39.18	238920		
28	35	1483.58	35.89	166296		
32	31.81	756.51	32.61	112136		
36	29.03	363.41	29.58	71536		
40	26.55	176.98	26.84	44656		

split

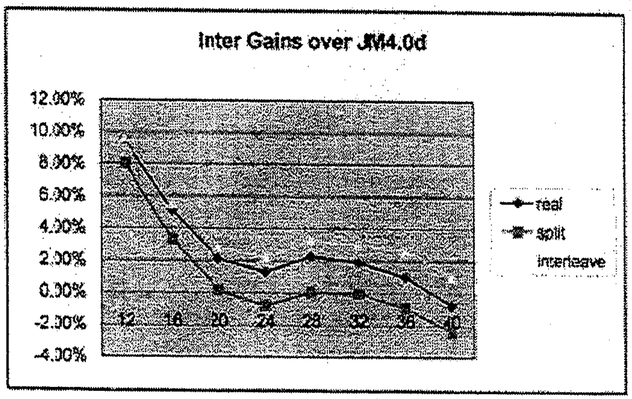
all			Intra			
	48.23	8933.07	50.0304	492328	8.00%	23.51%
	45.01	6303.24	46.5779	387448	3.30%	20.18%
	41.6	4139.17	42.8908	294416	0.13%	13.91%
	38.28	2581.17	39.3572	218864	-0.80%	8.39%
	35.08	1483.34	36.0091	157792	0.02%	5.11%
	31.93	758.8	32.6512	108392	-0.04%	3.34%
	29.11	366.82	29.5338	70848	-0.94%	0.96%
	26.56	181.33	26.8154	44992	-2.46%	-0.75%

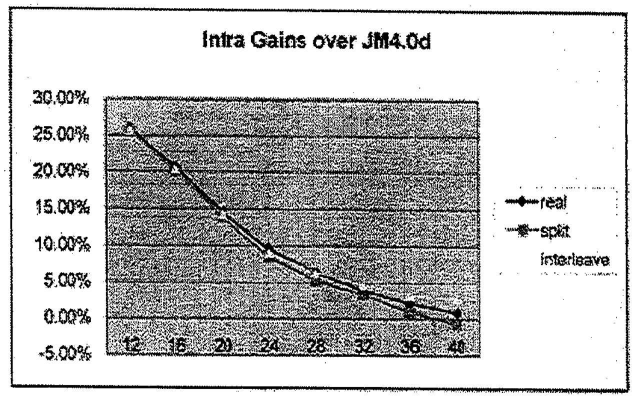
real

ALL		Intra			
48.23	[illegible]	49.9897	489240	9.55%	25.98%
45	6184.18	46.5601	385000	5.12%	20.68%
41.6	4056.64	42.8833	292264	2.12%	14.54%
38.29	2527.26	39.3298	216480	1.30%	9.39%
35.09	1449.62	36.0075	155840	2.29%	6.29%
31.97	743.89	32.6678	107800	1.93%	3.87%
29.16	359.72	29.5431	69992	1.02%	2.16%
26.57	178.35	26.8183	44288	-0.77%	0.82%

interleave

all		Intra			
48.22	8771.58	50.0354	491344	9.66%	25.66%
45	6159.83	46.547	386448	5.50%	20.39%
41.6	4025.56	42.3889	293344	2.87%	14.22%
38.29	2502.52	39.3253	217496	2.27%	8.97%
35.11	1434.52	35.9749	155872	3.31%	6.27%
31.99	735.38	32.5026	106880	3.05%	4.69%
29.2	353.65	29.5508	69184	2.69%	3.29%
26.65	175.14	26.3079	43360	1.04%	2.90%





JM4.0d

ALL

			Intra	
12	48.17	5741.08	49.68	459216
16	44.91	3748.89	46.35	334944
20	41.51	2319.59	42.73	237536
24	38.22	1424.31	39.19	163992
28	35.1	846.41	35.89	110744
32	32.18	481.6	32.78	72112
36	29.51	265.7	30.00	43064
40	27.01	147.36	27.64	26408

split

all

		Intra			
48.27	5430.83	50.0112	369280	5.40%	21.76%
45.01	3657.17	46.5756	281232	2.45%	16.04%
41.62	2313.94	42.6599	210144	0.24%	11.53%
38.35	1436.26	39.2661	150232	-0.84%	8.39%
35.21	854.16	35.9219	104176	-0.92%	5.93%
32.25	483.44	32.6941	66080	-0.38%	5.59%
29.57	266.76	29.9714	41656	-0.02%	3.27%
27.04	149.17	27.6737	26176	-0.89%	0.88%

real

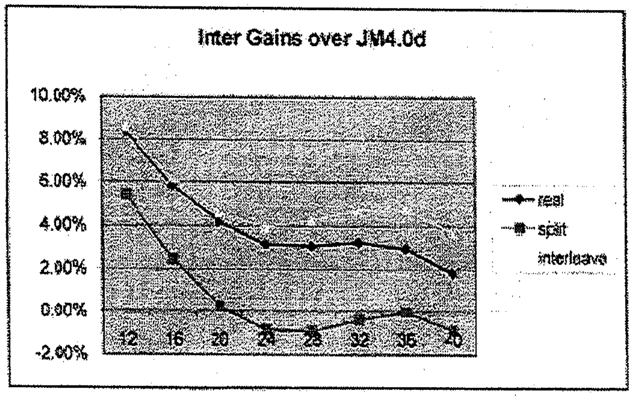
ALL

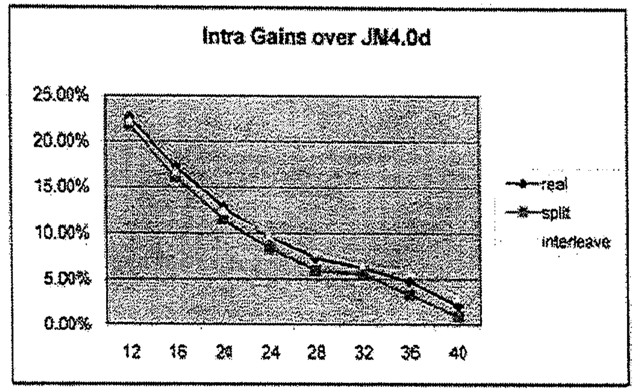
		Intra			
48.27	5255.26	49.9763	355400	3.39%	22.61%
45.01	3529.71	46.5263	277336	5.85%	17.20%
41.63	2222.29	42.8423	207120	4.19%	12.80%
38.37	1379.47	39.7527	148176	3.15%	9.64%
35.25	820.49	35.9499	102656	3.06%	7.30%
32.32	466	32.7788	67600	3.24%	6.26%
29.64	255.84	29.9605	41008	2.95%	4.77%
27.08	145.19	27.7231	25856	1.81%	2.09%

interleave

all

		Intra			
48.26	5246.65	49.9874	357136	3.58%	22.23%
45	3516.42	46.5245	279072	6.20%	16.68%
41.63	2212.57	42.8098	207936	4.61%	12.46%
38.39	1367.63	39.2646	147880	3.98%	9.82%
35.27	810.15	35.9355	101928	4.28%	7.96%
32.35	456.72	32.8308	67376	4.75%	6.57%
29.67	253.78	30.4034	40528	4.84%	5.89%
27.12	142.39	27.7116	25608	3.70%	3.03%



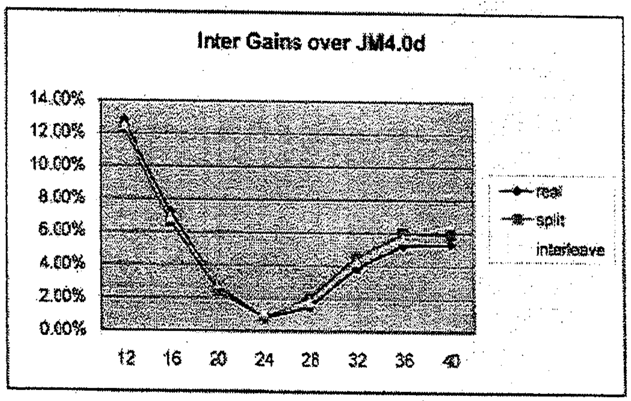


JM4.0d

	ALL		Intra			
12	48.72	9231.71	50.54	657472		
16	45.52	6509.12	47.34	508096		
20	41.93	4385.35	43.74	374548		
24	38.39	2890.01	40.12	268864		
28	34.94	1837.06	36.56	194936		
32	31.45	1096.93	33.01	138580		
36	28.1	599.38	29.57	94160		
40	24.97	299.67	26.39	62424		
	split					
	all		Intra			
	48.81	8103.29	50.9304	444184	12.22%	32.44%
	45.57	6081.12	47.7603	367144	6.58%	27.74%
	41.97	4278.98	44.0303	293184	2.43%	21.74%
	38.43	2865.78	40.2677	229960	0.84%	14.47%
	35.01	1800.14	36.7493	176896	2.01%	9.25%
	31.62	1049.32	33.113	132032	4.51%	4.79%
	28.41	563.8	29.6425	91776	5.94%	2.53%
	25.23	282.14	26.3483	61560	5.85%	1.38%

real

ALL		Intra			
48.81	8056.78	50.9187	443660	12.73%	32.52%
45.57	6040.71	47.7217	365712	7.20%	28.02%
41.99	4262.97	44.0403	292560	2.79%	21.91%
38.44	2866.72	40.2684	229640	0.61%	14.59%
35.03	1809.47	36.7314	176152	1.50%	9.64%
31.63	1056.48	33.1091	131280	3.86%	5.34%
28.38	567.92	29.5683	90832	5.25%	3.53%
25.21	283.74	26.3582	61096	5.32%	2.13%
interleave					
all		Intra			
48.79	8084.23	50.6654	438736	12.43%	33.27%
45.56	6062.1	47.7399	362912	6.87%	28.57%
41.97	4260.76	44.0031	291424	2.84%	22.21%
38.43	2857.02	40.2769	229168	1.14%	14.76%
35.04	1803.9	36.7378	175528	1.81%	9.96%
31.62	1052.17	33.0819	129792	4.26%	6.41%
28.4	565.22	29.6203	89000	5.70%	5.48%
25.25	280.07	26.4158	60084	6.54%	3.78%



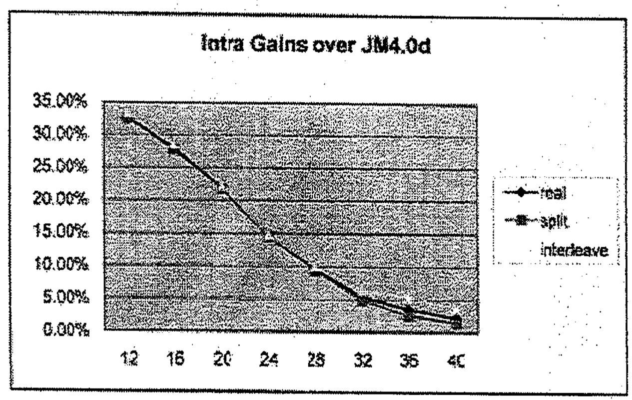


Exhibit C

lencod (Code in the encoder)

```
#if defined ABT_SCAN_INTERLEAVE
 for (j = 0; j < 16; j++)
 {
  // abt_mode scan order 3 = regular 4x4 scan
  if (abt_mode == 0)
  {
   // pitch = 8  interleave = 4
   c = coeff[ABT_SCAN[frm_fld][abt_mode][j*4 + param][0] +
          ABT_SCAN[frm_fld][abt_mode][j*4 + param][1]*8];
  }
  else if (abt_mode == 1)
  {
   // pitch = 8  interleave = 2
   c = coeff[ABT_SCAN[frm_fld][abt_mode][j*2 + param][0] +
          ABT_SCAN[frm_fld][abt_mode][j*2 + param][1]*8];
  }
  else if (abt_mode == 2)
  {
   // pitch = 4  interleave = 2
   c = coeff[ABT_SCAN[frm_fld][abt_mode][j*2 + param][0] +
          ABT_SCAN[frm_fld][abt_mode][j*2 + param][1]*4];
  }
  else
  {
   // pitch = 4  interleave = 1
   c = coeff[ABT_SCAN[frm_fld][abt_mode][j][0] +
          ABT_SCAN[frm_fld][abt_mode][j][1]*4];
  }
  if (c)
  {
   scoeff[k] = c;
   srun[k] = run;
   run = 0;
   k++;
  }
  ...........
```

```
  ........
  else
  {
   run++;
  }
 }
#else
 for (j = 0; j < 16; j++)
 {
  // abt_mode scan order 3 = regular 4x4 scan
  if (abt_mode == 0 || abt_mode == 1)
  {
   // pitch = 8
                                c =
coeff[ABT_SCAN[0][3/*abt_mode*/][j][0] +
          ABT_SCAN[0][3/*abt_mode*/][j][1]*8];
  }
  else
  {
   // pitch = 4
   c = coeff[ABT_SCAN[0][3/*abt_mode*/][j][0] +
          ABT_SCAN[0][3/*abt_mode*/][j][1]*4];
  }
  if (c)
  {
   scoeff[k] = c;
   srun[k] = run;
   run = 0;
   k++;
  }
  else
  {
   run++;
  }
 }
#endif // ABT_SCAN_INTERLEAVE
```

Exhibit D

ldecod (Code in the decoder)

- ldecod\src\abt.c (starting from line 773)

```
#if defined ABT_SCAN_INTERLEAVE
        ipos = -1;

        for (i = 0; i < numcoeff; i++)
        {
          ipos += (runarr[i]+1);
          assert(ipos<inumcoeff);
          ii = ABT_SCAN[frm_fld][abt_mode][ipos*4 + block][0];
          jj = ABT_SCAN[frm_fld][abt_mode][ipos*4 + block][1];
          img->m7[boff_x + ii][boff_y + jj] = levarr[i]*R[jj&1][ii&1]<<q_shift;
        }

#else
        ipos = -1;

        for (i = 0; i < numcoeff; i++)
        {
          ipos += (runarr[i]+1);
          assert(ipos<inumcoeff);
          ii = ABT_SCAN[frm_fld][3][ipos][0];
          jj = ABT_SCAN[frm_fld][3][ipos][1];
          img->m7[boff_x + ii + ((block&1)<<2)][boff_y + jj + ((block&2)<<1)] =
            levarr[i]*R[jj&1][ii&1]<<q_shift;
        }
#endif
```

Exhibit E

CERTIFICATION OF TRANSLATION

I, the undersigned, hereby declare that:

I am knowledgeable in both English and Japanese languages, and that I believe that the Japanese translation attached to this certification is a true and accurate translation of the e-mail attached hereto whose subject reads "Reverse Prediction Delay Notification."

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: June 26, 2009

Name: Tadashi Horie

Signature: Tadashi Horie

X-Mailer: QUALCOMM Windows Eudora Version 4.3.2-J
Date:
To: spg-visual
From: Satoshi Adachi <adachi>
Content-Type: multipart/mixed:
boundary="==============_18484329==_"
Subject: [epg-visual 267] Reverse Prediction Delay Notification Draft Patent Application

"How are you" from Adachi.
I am currently working on drafting patent applications for proposals to the next JVT meeting. I just completed drafting of one patent application and am sending it to you. I apologize for not advising you in advance, but I have already sent the draft patent application to a patent firm via our Intellectual Property Department because the due date for the proposals (midnight on the 4th) is closing in.

· Notifying and defining method used to adjust a decoded image output delay associated with a reverse prediction

In addition to this patent application, I will complete drafting of the following two patent applications as soon as I can and expect to hopefully have the applications filed this week.

· An output frame buffer managing method for a reverse prediction using multiple reference frames
· A method for applying context-adaptive variable-length coding to adaptive orthogonal transform size image encoding

Your comments would be appreciated.
Attachment: Patent Application.zip

X-Mailer: QUALCOMM Windows Eudora Version 4.3.2-J
Date: [redacted]
To: spg-visual
From: 安達 悟 <adachi>
Content-Type: multipart/mixed; boundary="=====================_18484329==_"
Subject: [spg-visual 267] 逆方向予測遅延量通知 特許明細書案

安達です。お疲れ様です。

次回JVT会合での提案に向けた特許明細書案を作成していますが、ようやく一件が形になりましたのでお送りします。前倒しですみませんが、寄書締切（４日深夜）も迫っており出願を急ぐべく、既に知財経由で特許事務所に送りました。

・逆方向予測における復号画像出力遅延調整のための通知、定義方法

この他、以下の２件の特許を急ぎ作成し、今週中の出願を目指す予定です。

・複数参照フレームによる逆方向予測における出力待ちフレームバッファ管理方法
・コンテキスト適応可変長符号化方法の可変直交変換サイズ映像符号化への適用方法

コメントいただければ幸いです。よろしくお願いいたします。

特許明細書[redacted].zip

Exhibit F

Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG
(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 Q.6)
5th Meeting: Geneva, Switzerland, 9-17 Oct, 2002

Document: JVT-E120
Filename: JVT-E120.doc

Title:	**CAVLC Cleanup to Accommodate ABT including Field Scans**
Status:	Input Document to JVT
Purpose:	Proposal

Author(s) or Contact(s): S.Adachi, S.Kato, T.K.Tan, and M.Etoh
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Source: NTT DoCoMo, Inc.

---

1 Introduction

In this document we propose to harmonize the CAVLC entropy decoding with the dedicated VLC decoding of the ABT decoding process.

CAVLC was designed to work on sub blocks of 4x4 coefficients, whereas ABT allows block sizes of 8x8, 8x4, 4x8 and 4x4.

A simple harmonization process where the block sizes of 8x8, 8x4 and 4x8 are subdivided into blocks of 4x4 is proposed. This would allow all entropy decoding to be done using the same CAVLC method without any modification.

2 Proposed Method.

2.1 Entropy coding

In this method we proposed that the scanning of the coefficients of the 8x8, 8x4, 4x8 and 4x4 be done as currently described in Sections 8.6.1 and 12.4.2. No changes are proposed to the scans be it the zig-zag scan or the field scan. The proposed method works equally well with all existing scans.

In the case of 8x8 block size, the resulting 64 scanned coefficients numbered from 0, 1, 2, 3, ...to 63 are redistributed into 4 groups where the first group comprises of 16 scanned coefficients numbered 0, 4, 8, ... to 60. The second group comprises of 16 scanned coefficients numbered 1, 5, 9, ... to 61. The third group comprises of 16 scanned coefficients numbered 2, 6, 10, ... to 62, and the fourth group comprises of 16 scanned coefficients numbered 3, 7, 11, ... to 63.

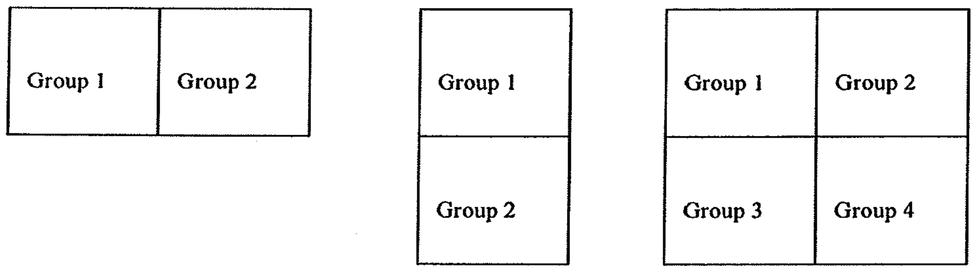
In the case of 4x8 and 8x4 block sizes, the resulting 32 scanned coefficients numbered from 0, 1, 2, 3, ... to 31 are redistributed into 2 groups where the first group comprises of 16 scanned coefficients numbered 0, 2, 4, ... to 30. The second group comprises of 16 scanned coefficients numbered 1, 3, 5, ... to 31.

No redistribution is needed for the case of 4x4 blocks.

All the groups of 16 scanned coefficients are then CAVLC decoded as described in section 9.1.6.

2.2 *Table Selection:*

For the purpose of determining N for the table selection the Groups are assumed to have the following physical locations



a) 8x4 blocks b) 4x8 blocks c) 8x8 blocks

3 Results

The experiment was conducted comparing the proposed solution to the performance of the JM4.0d implementation where the ABT blocks are coded using the dedicated VCL coding as described in Section 12.5.

For comparison purposes the results posted by RealNetworks on the reflector were also included.

The result shows that the proposed solution always perform better that the JM4.0d. For Inter coding a maximum improvement of up to 14.14% was observed with and average of 11.17% over all sequences. For Intra coding a maximum improvement of 40.03% was observed with and average of 30.50% over all sequence.

Inter							
		Real Networks			DoCoMo		
		MAX	MIN	AVE	MAX	MIN	AVE
	Foreman	8.18	-2.05	3.23	9.00	1.10	4.86
	Container	8.72	3.26	5.62	9.47	3.35	6.39
	Silent	10.77	-3.65	2.94	10.26	-0.82	3.98
QCIF	News	11.60	1.71	5.69	12.42	3.87	7.08
	Mobile	11.51	2.14	5.96	12.17	3.41	7.18
	Paris	9.67	3.07	5.24	10.31	4.48	6.37
	Tempete	10.93	0.47	4.47	11.99	3.19	6.01
	Bus	9.58	3.82	6.44	10.75	6.37	7.99
CIF	Flowergarden	13.80	0.68	7.05	14.14	2.24	8.02
	All	10.53	1.05	5.18	11.17	3.02	6.43

Intra								
		Real Networks			DoCoMo			
		MAX	MIN	AVE	MAX	MIN	AVE	
QCIF	Foreman	23.03	-1.34	9.32	22.55	1.34	9.71	
	Container	27.96	4.34	14.29	27.90	6.01	14.59	
	Silent	25.52	0.16	9.26	25.22	1.97	9.56	
	News	29.78	4.73	15.47	29.63	3.35	15.12	
CIF	Mobile	37.90	5.06	17.79	37.58	5.74	18.05	
	Paris	30.66	5.44	15.24	30.32	6.44	15.31	
	Tempete	33.30	1.15	13.54	33.23	2.82	13.86	
	Bus	28.60	4.41	12.58	28.06	4.72	12.68	
	Flowergarden	40.24	2.19	18.32	40.03	4.69	19.34	
	All	30.78	2.91	13.98	30.50	4.12	14.25	

Similarly the performance of the proposed solution also improves for the cases involving interlace material and field scans.

4 Conclusions

We propose to harmonize the VLC coding into a single method. There is no additional cost in complexity apart for reorganizing the scanned coefficients and the entropy decoding is simplified.

The simplification also results in improved coding efficiency of up to 14.14 % in inter coding and 40.03% in intra coding.

The proposed text is provided below.

5 Proposed Text:

5.1 Modification 1:

Merge Subclause 8.6.1 Zig Zag Scan with Subclause 12.4.2

Replace first paragraph (including Figure 8-12) and last paragraph

With

Subclause 12.4.2

While retaining 2nd and 3rd paragraphs

5.2 Modification 2:

Replace the last two paragraphs of subclause 9.1.6

Zig-zag scanning as described in subclause 9.4.1 is used, but in the decoding of coefficient data, both levels and runs, the scanning is done in reverse order. Therefore the signs of T1s are decoded first (in reverse order), then the

Level information of the last coefficient in the zig-zag scan order not included in the T1s, and so on. Run information is decoded similarly. First Total number of zeros in Runs is decoded, followed by Run before the last nonzero coefficient in the zig-zag scan order, and so on.

If adaptive_block_size_transform_flag == 1, the VLC method for decoding 4x4, 4x8, 8x4, and 8x8 luma coefficient blocks is specified in subclause 12.5.1.

With

In decoding of coefficient data, both levels and runs, the scanning is done in reverse order. Therefore the signs of T1s are decoded first (in reverse order), then the Level information of the last coefficient in the zig-zag scan order not included in the T1s, and so on. Run information is decoded similarly. First Total number of zeros in Runs is decoded, followed by Run before the last nonzero coefficient in the zig-zag scan order, and so on.

The above decoding operation results in groups of 16 zig-zag scanned coefficients.

In the case of 8x8 block size, four groups of 16 scanned coefficients are decoded in the above manner. These four groups of scanned coefficients are then combined in an interleave manner taking one coefficient from each group iteratively, starting with the first group, to form a single array of 64 scanned coefficients.

In the case of 4x8 and 8x4 block sizes, two groups of 16 scanned coefficients are decoded in the above manner. These two groups of scanned coefficients are then combined in an interleave manner taking one coefficient from each group iteratively, starting with the first group, to form a single array of 32 scanned coefficients.

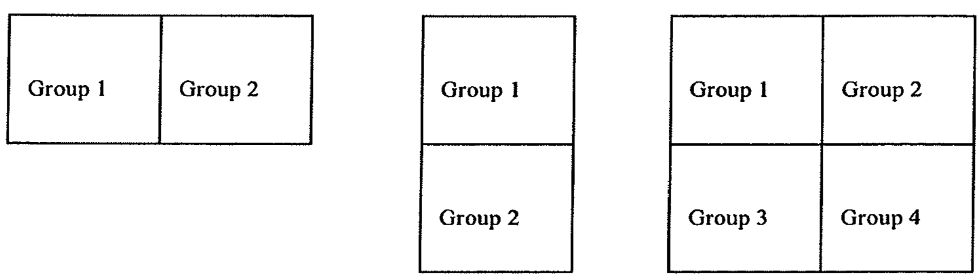
No interleaving is necessary for the case of 4x4 block size.

The arrays of 16, 32 and 64 scanned coefficients are then inverse zig-zag scanned according to the zig-zag and field scans as described in subclause 8.6.1.

5.3 Modification 3:

Add to subclause 9.1.6.2 Table selection before the Tale 9-8.

For the purpose of determining N for the table selection the groups of 16 scanned coefficients decoded in subclause 9.1.6 are assumed to have the following physical locations



a) 8x4 blocks b) 4x8 blocks c) 8x8 blocks

(Append for Proposal Documents)

JVT Patent Disclosure Form

International Telecommunication Union
Telecommunication Standardization Sector

International Organization for Standardization

International Electrotechnical Commission

Joint Video Coding Experts Group - *Patent Disclosure Form*

(Typically one per contribution and one per Standard | Recommendation)

Please send to:
JVT Rapporteur Gary Sullivan, Microsoft Corp., One Microsoft Way, Bldg. 9, Redmond WA 98052-6399, USA
Email (preferred): Gary.Sullivan@itu.int Fax: +1 425 706 7329 (+1 425 70MSFAX)

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Submitting Organization or Person:

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Place and date of submission	Geneva, Switzerland, 9-17 Oct, 2002

Relevant Recommendation | Standard and, if applicable, Contribution:

Name (ex: "JVT")	**JVT**
Title	**CAVLC Cleanup to Accommodate ABT including Field Scans**
Contribution number	**JVT-E120**

(Form continues on next page)

Disclosure information – Submitting Organization/Person (choose one box)

☐ 2.0 The submitter is not aware of having any granted, pending, or planned patents associated with the technical content of the Recommendation | Standard or Contribution.

or,

The submitter (Patent Holder) has granted, pending, or planned patents associated with the technical content of the Recommendation | Standard or Contribution. In which case,

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☐ 2.3 The Patent Holder is unwilling to grant licenses according to the provisions of either 2.1, 2.2, or 2.2.1 above. In this case, the following information must be provided as part of this declaration:

- patent registration/application number;
- an indication of which portions of the Recommendation | Standard are affected.
- a description of the patent claims covering the Recommendation | Standard;

In the case of any box ***other than 2.0*** *above, please provide the following:*

Patent number(s)/status ______________________________

Inventor(s)/Assignee(s) ______________________________

Relevance to JVT ______________________________

Any other remarks: ______________________________

(please provide attachments if more space is needed)

(form continues on next page)

Third party patent information – fill in based on your best knowledge of relevant patents granted, pending, or planned by other people or by organizations other than your own.

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For box 3.2, please provide as much information as is known (provide attachments if more space needed) - JVT will attempt to contact third parties to obtain more information:

3rd party name(s) ____________________

Mailing address ____________________
Country ____________________
Contact person ____________________
Telephone ____________________
Fax ____________________
Email ____________________
Patent number/status ____________________
Inventor/Assignee ____________________
Relevance to JVT ____________________

Any other comments or remarks:

Exhibit G

CERTIFICATION OF TRANSLATION

I, the undersigned, hereby declare that:

I am knowledgeable in both English and Japanese languages, and that I believe that the Japanese translation attached to this certification is a true and accurate translation of the Japanese document attached hereto and entitled "REQUEST FOR FILING OF PATENT APPLICATION."

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: June 26, 2009

Name: Tadashi Horie

Signature:

IP No. 04767
October 8, 2002

ATTN: Yoshiki HASEGAWA, President
SOEI Intellectual Property Law
FROM: Yoshitaro SHIMANUKI
Director, Intellectual Property Department
NTT DoCoMo /*Seal of NTT DoCoMo Intellectual Property Department*/

REQUEST FOR FILING OF PATENT APPLICATION

We hereby request that you file an application for a domestic patent as described below, and undertake the proceedings on our behalf.

In the event that you are unable to take this application filing, please advise us within 10 days.

Regards.

DESCRIPTION

1. Type of Invention	Patent
2. NTT DoCoMo Docket Number	14-0422
3. Method of Filing	Ordinary filing of application
4. Date of Mailing	October 8, 2002
5. Deadline for Filing Application	October 8, 2002
6. Plan to Announce Externally	Yes (October 9, 2002)
7. Related Applications	None
8. Request for Examination	Advised later
9. Power of Attorney	General power of attorney shall apply
10. Patent Search Prior to Filing	None
11. Procedure and Payment of Fees	Domestic Patent Filing Contract applies (dated March 14, 2002)
12. Special Items	None
13. Related Key Words	Image (moving image) encoding, moving image encoding, orthogonal transform, entropy (variable length) coding

14. Appended Documents

(1) Draft of Specification	1 copy
(2) Summary of the Invention	1 copy
(3) Table of Names of Inventors	1 copy

FAXED 10/8/2002 SENT 10/9/2002

[Contact Person for This Matter]
Manager of Intellectual Property Rights, Intellectual Property Department

Manager of Administration: WATANABE TEL: FAX:
Manager of Technology: TANAKA TEL: FAX:

/Date stamp: 10/8/2002/
14-0422

[Title of the Invention]

IMAGE ENCODING METHOD, IMAGE DECODING METHOD, IMAGE ENCODING APPARATUS, IMAGE DECODING APPARATUS, IMAGE TRANSMISSION SYSTEM, IMAGE STORING SYSTEM, AND IMAGE REPRODUCTION SYSTEM, CAPABLE OF IMPLEMENTING EFFICIENT ENTROPY CODING OF ORTHOGONAL TRANSFORM COEFFICIENTS, IN AN ORTHOGONAL TRANSFORM PERMITTING SELECTION AMONG MULTIPLE BLOCK SIZES

[Claims]

<Encoding Method Claim – Basic Claim>

[Claim 1]

An image encoding method of dividing image signals into blocks, performing an orthogonal transform, sequentially reading resultant orthogonal transform coefficients to obtain a coefficient string, and performing entropy coding thereon, the image encoding method comprising:

a means for selecting a size of a block for the orthogonal transform, out of a plurality of blocks of different sizes;

a means for performing entropy coding adapted to the coefficient string in a block of the minimum size from among the plurality of blocks;

a means for dividing, when a block of a larger size is selected, the coefficient string in the block into a plurality of coefficient strings formed from a number of coefficients equal to a number of coefficients of a coefficient string in a block of the minimum size,; and

a means for entropy encoding of the divided coefficient string.

<Encoding Method Claim, Coefficient Dividing Method, Alternating Readout>

[Claim]

An image encoding method according to claim 1, wherein the means for dividing the coefficient string is configured to sequentially read the coefficients of the coefficient string from the low frequency region and to alternately assign them to the plurality of coefficient strings formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, thereby obtaining the divided coefficient strings.

<Encoding Method Claim, Coefficient Dividing Method, For Each Frequency Band>

[Claim]

An image encoding method according to claim 1, wherein the means for dividing the coefficient string is configured to sequentially read the coefficients of the coefficient string from the low frequency region, to read only the number of coefficients equal to the number of coefficients of a coefficient string in a block of minimum size, and to repeatedly perform this to obtain divided coefficient strings.

<Decoding Method Claim – Basic Claim>

[Claim]

An image decoding method of decoding data encoded by dividing image signals into blocks, performing an orthogonal transform, sequentially reading resultant orthogonal transform coefficients to obtain a coefficient string, and performing entropy coding thereof, the image decoding method comprising:

a means for selecting a size of a block for the orthogonal transform, out of a plurality of blocks of different sizes;

a means for decoding data encoded by entropy coding adapted to the coefficient string in a block of the minimum size from among the plurality of blocks;

a means for constructing when a block of a larger size is selected, the coefficient string with the same number of coefficients included in the block from a plurality of coefficient strings formed from a number of coefficients equal to a number of coefficients of a coefficient string in a block of the minimum size ; and

a means for decoding the plurality of coefficient strings from the encoded data.

<Decoding Method Claim, Coefficient Dividing Method, Alternating Readout>

[Claim]

An image decoding method according to claim 1 (*sic*), wherein the means for constructing the coefficient string is configured to read, from the low frequency regions, the respective coefficients alternately from the plurality of coefficient strings each formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, writing them into a new coefficient string, thereby obtaining the constructed coefficient string.

<Decoding Method Claim, Coefficient Dividing Method, For Each Frequency Band>

[Claim]

An image decoding method according to claim 1 (*sic*), wherein the means for constructing the coefficient string is configured to read all of the coefficients of a single coefficient string from the low frequency region, from the plurality of coefficient strings formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, repeatedly writing them into a new coefficient string, thereby obtaining the constructed coefficient strings.

<Apparatus Claim>

[Claim]

<System Claim>

[Claim]

An image processing system formed from an image encoding apparatus and an image decoding apparatus, wherein the encoding apparatus comprises an image encoding apparatus of any one of claims to ; and an image decoding apparatus of any one of claims to .

<Computer Encoding Program>

[Claim]

An image encoding program for executing the steps of the image encoding method according to any of claims to , in a computer used as an image encoding apparatus.

<Computer Decoding Program>

[Claim]

An image decoding program for executing the steps of the image decoding method according to any of claims to , in a computer used as an image decoding apparatus.

[Detailed Description of the Invention]

[Technical Field]

The present invention relates to an image encoding method, an image decoding method, an image encoding apparatus, an image decoding apparatus, an image transmission system, an image storing system, and an image reproduction system.

[Prior Art]

Encoding techniques of image signals are used for transmission and for storing and reproducing image signals of still images, moving images, and so on. Such techniques include known international standard encoding methods, e.g., ISO/IEC International Standard 10918 (hereinafter referred to as JPEG) as an encoding technique for still images, and ISO/IEC International Standard 14496-2 (MPEG-4 Visual, which will be referred to hereinafter as MPEG-4) as an encoding technique for moving images. A newer known encoding method is ITU-T Recommendation H.264; ISO/IEC International Standard 14496-10 (Joint Final Committee Draft of Joint Video Specification, ftp//ftp.imtc-files.org/jvt-experts/2002_07_Klagenfurt/JVT-D157.zip, which will be referred to hereinafter as H.26L), which is a video encoding method intended for joint international standardization by ITU-T and ISO/IEC. An example of a reference pertaining to typical encoding techniques used in these image encoding methods is *Kokusai hyojun gazo fugoka no kiso gijutsu* [Basic Technologies of International Image Coding Standards] by Fumitaka Ono and Hiroshi Watanabe, published March 20, 1998 by Corona Publishing Co., Ltd.

Image signals demonstrate close correlations between spatially neighboring pixels and thus transformation into the frequency domain leads to deviation of information to the low frequency region, which enables reduction of redundancy by making use of the deviation. Therefore, the typical image encoding methods adopt a technique of subjecting image signals to an orthogonal transform to transform them into orthogonal transform coefficients in the frequency domain, so as to achieve deviation of signal components to the low frequency region. Furthermore, the coefficient values are quantified so that small-valued coefficients are converted to zero-valued coefficients. A coefficient string is made by sequentially reading the coefficients from the coefficients in the low frequency region and is subjected to entropy coding to take advantage of the coefficient values, thus achieving efficient encoding with reduction of redundancy.

In this case, the Discrete Cosine Transform (DCT) is commonly used in terms of encoding efficiency and ease of implementation. The orthogonal transform such as the DCT is carried out in units of blocks resulting from division of image signals into blocks each consisting of a plurality of pixels. The size of the blocks, as well as the property of the image signals, largely affects the encoding efficiency.

When image signals demonstrate only small change in the spatial property, image signals to be transformed into orthogonal transform coefficients in a similar frequency region are widely distributed on an image, and the redundancy can be reduced more with increase in the size of the

blocks, i.e., the size of the orthogonal transform, so as to increase the encoding efficiency, as compared with using smaller blocks, which raise the need for repeatedly expressing identical orthogonal transform coefficients. When image signals demonstrate large change in the spatial property on the other hand, the increase in the size of the blocks results in obtaining orthogonal transform coefficients havingvarious frequency components, thus decreasing the deviation of coefficients, which makes efficient entropy coding difficult and thus decreases the encoding efficiency.

In order to take advantage of the change of encoding efficiency due to the changes in the sizes of the blocks for the orthogonal transform and the property of image signals, the technology utilized is one of preparing orthogonal transform means adapted for a plurality of block sizes in advance and adaptively selecting and using a size achieving the best encoding efficiency out of them. This technology is called Adaptive Block size Transforms (ABT) and is adopted in H.26L. FIG. 1 shows orthogonal transform blocks used for ABT in H.26L. The ABT permits a size achieving the best encoding to be selected out of four types of orthogonal transform block sizes shown in FIGS. 1 (b) – 1 (e), for each macroblock of 16 x 16 pixels shown in FIG. 1 (a). Pixel values of the macroblocks are equally divided in blocks, according to the selected size and are then subjected to the orthogonal transform. By implementing such selection, it becomes feasible to achieve efficient reduction of redundancy through the use of the orthogonal transform in accordance with the change in the spatial property of image signals in the macroblocks. Reference should be made to H.26L as to more specific details of the ABT.

The entropy coding for the orthogonal transform coefficients obtained by the orthogonal transform is effected on a coefficient string obtained by sequentially reading the orthogonal transform coefficients from the coefficients in the low frequency region. FIG 2 (a) shows an order of reading coefficients in an orthogonal transform block of 4 x 4 pixels. Since the coefficients obtained by the orthogonal transform are arranged with the lowest frequency component (i.e., the direct current component) at the upper left corner, the coefficients are read out in order from the upper left coefficients to obtain a coefficient string consisting of sixteen coefficients as shown in FIG. 2 (b). This reading order is called zig-zag scan.

The coefficients obtained by the orthogonal transform are noncorrelated with each other, and the signal components deviate to the low frequency region. For this reason, when they are further quantized, the lower frequency coefficients are more likely to be nonzero coefficient values, so that many zero-valued coefficients appear in the coefficient string. For example, it produces a sequence of coefficient values as shown in FIG. 2 (c). Therefore, for efficient entropy coding of the coefficient string of this distribution, it is common practice in encoding of images to perform the encoding by expressing the coefficient string by the numbers of continuous zero coefficients preceding a nonzero coefficient (runs) and coefficient values (levels) of the nonzero coefficients. Such encoding with runs and levels is also used in the entropy coding of orthogonal transform coefficients by the ABT.

On the other hand, in order to increase the efficiency more in the entropy coding as described above, H.26L employs a technology called Context-based Adaptive Variable Length Code (CAVLC), which is applied to the orthogonal transform without the use of ABT, i.e., to

cases where the orthogonal transform is always carried out in units of orthogonal transform blocks of 4 x 4 pixels.

The CAVLC in H.26L utilizes the following features: the maximum number of coefficients in the coefficient string obtained from the orthogonal transform blocks of 4 x 4 pixels is 16; the magnitude of runs is restricted by this maximum number; and the magnitude of levels tends to be larger at lower frequencies. A large number of encoding tables used in variable length encoding are prepared as optimized tables for respective conditions, and they are applied while being sequentially switched, so as to increase the encoding efficiency.

For example, in the case where runs are encoded in order, the first run can take a variety of values from 0 to 14 (according to the definition of runs in H.26L, the maximum number of runs is 14, which is only two smaller than the total number of coefficients). On the other hand, runs appearing in the last stage of the sequential coding of runs can take only limited run values, because there is an upper limit to the number of coefficients in the coefficient string. Accordingly, as shown in FIG. 3, the right-side encoding table with the largest number of elements of the encoding table is applied to the runs appearing in the initial stage, and the left-side encoding tables with the smaller number of elements of the encoding table are applied to runs appearing in the last stage. This permits assignment of codes of smaller bit counts and thus implements efficient entropy coding. The CAVLC achieves the efficient encoding by making use of the conditions such as the maximum number of coefficients in the blocks, and by placing restrictions on the range where values to be encoded can take. Reference should be made to H.26L as to more specific details of the CAVLC.

[Problems to be Solved by the Invention]

By applying the foregoing CAVLC to the ABT, it can be expected that more efficient entropy coding will also be achieved in the coefficient strings of the ABT.

However, the CAVLC achieves the increase in encoding efficiency by optimizing the encoding tables used in variable length coding for the respective conditions, based on the maximum number of coefficients in the blocks, and applying the encoding tables to the switching while switching among them.

When ABT is used, the number of coefficients differ in each of the blocks which differ in size: 64 in the case of 8 x 8 blocks in FIG. 1 (b), 32 in the case of 8 x 4 and 4 x 8 blocks in FIGS. 1 (c) and 1 (d), and 16 in the case of 4 x 4 blocks in FIG. 1 (e). For this reason, the application of the CAVLC requires consideration be given to the huge number of conditions that can occur in the respective cases.

For example, supposing the encoding tables are set according to the maximum number of coefficients in coefficient strings, like the encoding tables of runs shown in FIG. 3, a huge number of encoding tables must be prepared: in the case of 8 x 8 blocks with the number of coefficients being 64, it is necessary to prepare the encoding tables ranging from the encoding table with the number of elements being 2 to the encoding table with the number of elements being 62. Likewise, in the cases of 8 x 4 and 4 x 8 blocks with the number of coefficients being

32, the encoding tables must be prepared from that of the number of elements being 2 to that of the number of elements being 30.

When it was attempted to apply the entropy coding optimized for characteristics of coefficients like the CAVLC to the orthogonal transforms selectively using the orthogonal transform blocks of different sizes like the ABT as described above, there was the problem that the number of encoding tables to be prepared became huge, and the memory capacity necessary for retention of the encoding tables became large. Since it also involved the use of different encoding tables for blocks of the respective sizes, as well as different selection procedures thereof, there was the problem that the procedure in the entropy coding became complicated, and thus the implementing means and the apparatus structure became complicated.

The present invention has been accomplished in order to solve the above problems, and an object of the present invention is to provide an image encoding method, an image decoding method, an image encoding apparatus, an image decoding apparatus, an image transmission system, an image sotring system, and an image reproduction system enabling efficient entropy coding in the orthogonal transform of variable sizes.

[Means for Solving These Problems]

<Encoding Method Claim -- Basic Claim>

In order to achieve the above object, the present invention provides an image encoding method of dividing image signals into blocks, performing an orthogonal transform, sequentially reading resultant orthogonal transform coefficients to obtain a coefficient string, and performing entropy coding thereon, the image encoding method comprising:

a means for selecting a size of a block for the orthogonal transform, out of a plurality of blocks of different sizes;

a means for performing entropy coding adapted to the coefficient string in a block of the minimum size from among the plurality of blocks;

a means for dividing, when a block of a larger size is selected, the coefficient string in the block into a plurality of coefficient strings formed from a number of coefficients equal to a number of coefficients of a coefficient string in a block of the minimum size,; and

a means for entropy encoding of the divided coefficient string.

Accordingly, in the image encoding method according to the present invention, when a block of a larger size is selected to be subjected to the orthogonal transform, the coefficient string in that block is first divided into coefficient strings and then the entropy coding is performed. This permits the entropy coding adapted to the coefficient string in the block of the minimum size to be applied in entropy coding of the coefficient string, whereby it is feasible to implement efficient entropy coding of orthogonal transform coefficients, without complicating the procedure of entropy coding.

<Encoding Method Claim, Coefficient Dividing Method, Alternating Readout>

The means for dividing the coefficient string is configured to sequentially read the coefficients of the coefficient string from the low frequency region and to alternately assign them to the plurality of coefficient strings formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, thereby obtaining the divided coefficient strings.

<Encoding Method Claim, Coefficient String Dividing Method, For Each Frequency Band>

The means for dividing the coefficient string is configured to sequentially read the coefficients of the coefficient string from the low frequency region, to read only the number of coefficients equal to the number of coefficients of a coefficient string in a block of minimum size, and to repeatedly perform this to obtain divided coefficient strings.

<Decoding Method Claim – Basic Claim>

Tthe present invention also provides an image decoding method of decoding data encoded by dividing image signals into blocks, performing an orthogonal transform, sequentially reading resultant orthogonal transform coefficients to obtain a coefficient string, and performing entropy coding thereof, the image decoding method comprising:

a means for selecting a size of a block for the orthogonal transform, out of a plurality of blocks of different sizes;

a means for decoding data encoded by entropy coding adapted to the coefficient string in a block of the minimum size from among the plurality of blocks;

a means for constructing when a block of a larger size is selected, the coefficient string with the same number of coefficients included in the block from a plurality of coefficient strings formed from a number of coefficients equal to a number of coefficients of a coefficient string in a block of the minimum size ; and

a means for decoding the plurality of coefficient strings from the encoded data.

Accordingly, in the image decoding method according to the present invention, when a block of a larger size is selected to implement decoding of the encoded data subjected to the orthogonal transform, the coefficient string in that block is constructed from coefficient strings comparable to that block. This permits the decoding of coefficient strings from data encoded by using entropy coding adapted to the coefficient string in the block of the minimum size, whereby it is feasible to implement efficient entropy coding of orthogonal transform coefficients, without complicating the procedure of entropy coding.

<Decoding Method Claim, Coefficient Dividing Method, Alternating Readout>

The means for constructing the coefficient string is configured to read, from the low frequency regions, the respective coefficients alternately from the plurality of coefficient strings each formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, writing them into a new coefficient string, thereby obtaining the constructed coefficient string.

<Decoding Method Claim, Coefficient Dividing Method, For Each Frequency Band>

The means for constructing the coefficient string is configured to read all of the coefficients of a single coefficient string from the low frequency region, from the plurality of coefficient strings formed from a number of coefficients equal to the number of coefficients of a coefficient string in a block of the minimum size, repeatedly writing them into a new coefficient string, thereby obtaining the constructed coefficient strings.

[Embodiments of the Invention]

<First Embodiment>

The preferred embodiments of the image encoding method, image decoding method, image encoding apparatus, image decoding apparatus, image transmission system, image storing system, and image reproduction system according to the present invention will be described in detail below with reference to the drawings.

The description will be based on the premise that the encoding and decoding in the description hereinafter are implemented on the basis of H.26L, and the part without specific description about the operation in the image encoding is supposed to conform to the operation of H.26L. However, the present invention is not limited to H.26L.

An embodiment of the present invention will be described. In the encoding according to the present embodiment, orthogonal transform coefficients in blocks of the respective sizes of the ABT in H.26L are divided into a plurality of coefficient strings consisting of coefficients in a number equal to the number of coefficients in a coefficient string of a 4 x 4 block. This makes it feasible to perform the entropy coding by the CAVLC of H.26L defined so as to be adapted to the 4 x 4 blocks.

It is assumed that in the encoding, first, the ABT in H.26L is applied to one macroblock, a size achieving the best encoding efficiency is selected out of the blocks shown in FIGS. 1 (b)-(e), and the orthogonal transform is effected in units of blocks of the selected size.

It is also assumed that the CAVLC in H.26L is employed in the entropy coding of orthogonal transform coefficients. Namely, it is assumed that only the variable length encoding adapted to the encoding of orthogonal transform coefficients for the 4 x 4 block shown in FIG. 1 (e) is defined.

For example, let us suppose herein that the 8 x 8 block in FIG. 1 (b) is selected. The following readout operation of reading the orthogonal transform coefficients is carried out for this 8 x 8 block. First, 64 coefficients in the 8 x 8 block are read out by zig-zag scan as shown in FIG. 4 (a), to obtain a coefficient string as shown in FIG. 4 (b).

Then, this coefficient string is divided into four coefficient strings each consisting of sixteen coefficients, the number of which is the same as the number of coefficients in the coefficient string of the 4 x 4 block. Here the coefficients in the original coefficient string are read out from the low frequency region and alternately assigned respectively to the four

coefficient strings, thereby obtaining the divided coefficient strings. FIGS. 4 (c) and 4 (d) show this readout operation. Since the coefficients are alternately assigned to the respective coefficient strings from the coefficients in the low frequency region, the coefficients read out in the order of the 0^{th}, 4^{th}, 8^{th}, 12^{th} ... in the original coefficient string are each read out and assigned to the first divided coefficient string, and the coefficients read out in order of the 1^{st}, 5^{th}, 9^{th}, 13^{th} ... in the original coefficient string are each read out and assigned to the second divided coefficient string. The third and fourth divided coefficient strings are not illustrated in FIG. 4.

Similarly, when the 8 x 4 block or the 4 x 8 block of FIG. 1 (c) or FIG. 1 (d) is selected, 32 coefficients are divided into two coefficient strings consisting of 16 coefficients. The readout method for obtaining the divided coefficient strings is also similar to that in the case of the 8 x 8 block, except that the number of coefficient strings alternately assigned is 2 instead of 4. The coefficients in the original coefficient string are read out from the low frequency region and alternately assigned to the two coefficient strings.

The coefficient strings obtained in this way are entropy encoded according to entirely the same procedure as the encoding of CAVLC when ABT is not used, and outputted in order as encoded data of orthogonal transform coefficients in the ABT block.

At this time, the CAVLC of H.26L utilizes the space context to switch the applied encoding table on the basis of the number of nonzero coefficients in an adjacent 4 x 4 block. For this reason, arrangements of coefficient strings in the ABT blocks larger than the 4 x 4 block after division are defined. The definitions are shown in FIG. 5. For example, the 8 x 8 block shown in FIG, 5 (a) is handled such that the first divided coefficient string illustrated in FIG, 4 (c) is located at the position of "1" and the second divided coefficient string illustrated in FIG, 4 (d) is located at the position of "2." Using the definitions of this arrangement, the space context for the divided coefficient strings in the ABT blocks, or the space context for the 4 x 4 blocks adjacent to the ABT blocks is handled as in the technique of the CAVLC in H.26L without any change.

In the decoding, the original orthogonal transform matrix can be obtained according to a procedure reverse to the procedure in encoding.

Let us suppose that the ABT in H.26L is applied to one macroblock, a size is designated out of the blocks shown in FIG. 1 (b) – (e), and encoded data for this macroblock results from the orthogonal transform carried out in units of the ABT block.

At this time the encoded data contains encoded data obtained by entropy coding of the divided coefficient strings by the CAVLC, in order as encoded data of orthogonal transform coefficients in the ABT blocks. Accordingly, it is sequentially decoded according to the procedure of the CAVLC to obtain the divided coefficient strings.

Since these divided coefficient strings are coefficient strings divided by the readout method shown in FIG. 4, the original orthogonal transform coefficient block can be obtained by conversely writing the coefficients of the divided coefficient strings into the original coefficient string and further writing the resultant coefficient strings into the orthogonal transform

coefficient block. The procedure thereafter is the same as the decoding procedure with application of the ABT in H.26L.

In the present embodiment, the zig-zag scan was applied to readout of orthogonal transform coefficients, but the readout method of coefficients in application of the present invention does not have to be limited to the zig-zag scan. For example, the present invention may also be applied to cases of application of a field scan for field encoding in interlaced images, which is defined in the ABT of H.26L. In this application, the dividing technique of the coefficient strings in the present embodiment can be applied as it is.

The present embodiment showed the readout method for obtaining the coefficient strings after division as the alternating readout shown in FIG. 4, but it is also possible to obtain the divided coefficient strings by another readout method different therefrom. For example, as shown in FIGS. 6 (c) and 6 (d), sixteen consecutive coefficients are each read out from the original coefficient string from the low frequency region and each of them may be assigned to one of the divided coefficient strings.

In the present embodiment, the readout of orthogonal transform coefficients in the encoding is implemented so as to perform a first readout for obtaining the coefficient string from the orthogonal transform block, and then to perform a second readout for obtaining a plurality of divided coefficient strings. The writing of orthogonal transform coefficients in the decoding is implemented so as to perform a first writing for obtaining the constructed coefficient strings, and then to perform a second writing for obtaining the orthogonal transform block. However, the readout and writing of coefficients according to the present invention do not have to be limited to these methods, but may also be implemented by a variety of readout and writing methods that can obtain coefficient strings in the desired arrangement. For example, it is also possible to implement such readout as to immediately obtain a plurality of divided coefficient strings in the first coefficient readout from the orthogonal transform block. The writing from the divided coefficient strings may also be performed so as to immediately obtain the orthogonal transform block in the first coefficient writing.

In the present embodiment, the divided coefficient strings were arranged as shown in FIG. 5, and the space context from the adjacent 4 x 4 blocks is assumed to be handled by the CAVLC in H.26L without any change. However, at this time, the coefficient strings divided from the coefficient strings of the ABT blocks larger than the 4 x 4 blocks can be considered as having properties essentially different from the coefficient strings in the case of the original 4 x 4 block, and weight may be given to the numerical values used as the space context. Specifically, the number of nonzero coefficients can be used as the space context from the adjacent blocks, but the number of nonzero coefficients for the divided coefficient strings obtained from ABT blocks larger than the 4 x 4 blocks may be added with or multiplied by a constant when used as the space coefficient. Alternatively, when divided coefficient strings are obtained by continuously reading out the coefficients from the low frequency region as shown in FIG. 6, different constants may be added to or multiplied by coefficients read out from the low frequency region and coefficients read out from the high frequency region.

The description of the present embodiment was implemented on the basis of H.26L, and the description was based on the ABT and CAVLC in the H.26L. However, the image encoding methods to which the present invention can be applied are not limited to H.26L, and it is possible to apply the present invention to a variety of image encoding methods permitting selection from a plurality of block sizes for the orthogonal transform and using entropy coding adapted to the orthogonal transform coefficients.

[Advantageous Effects of the Invention]

The image encoding method, image decoding method, image encoding apparatus, image decoding apparatus, image transmission system, image storing system, and image reproduction system according to the present invention, as described in detail above, yield the following advantageous effects. Efficient entropy coding can be achieved without increasing the number of encoding tables in entropy coding, and without complicating the encoding tables and their selection procedure, by dividing the coefficient strings formed from resultant orthogonal transform coefficients into a plurality of coefficient strings equal in size to that of a coefficient string in a block of the minimum size, in cases where it is possible to select the size of the blocks for orthogonal transform from a plurality of blocks, and performing entropy coding adapted to the coefficient string in the block of the minimum size.

[Brief Description of the Drawings]

[FIG. 1]

Diagram illustrating an orthogonal transform block used in Adaptive Block size Transforms (ABT) of H.26L.

[FIG. 2]

Diagram illustrating the readout method of coefficients in a 4 x 4 block, and an example of a coefficient string after readout.

[FIG. 3]

Diagram illustrating an encoding table of runs used in Context-based Adaptive Variable Length Code (CAVLC) of H.26L.

[FIG. 4]

Diagram illustrating an example of readout and dividing of orthogonal transform coefficients according to the present invention, performed on an 8 x 8 block.

[FIG. 5]

Diagram illustrating definitions of arrangements of coefficient strings after division according to the present invention, within the original blocks.

[FIG. 6]

Diagram illustrating an example of another method of readout and dividing of orthogonal transform coefficients according to the present invention, performed on an 8 x 8 block.

[Type of Document] Abstract
[Abstract]
[Problem]
[Means]

SUMMARY OF THE INVENTION

Format – 1 (4/4)
MSWord with adaptation for handwriting

1. Title of the Invention

Image Encoding Method, Image Decoding Method, Image Encoding Apparatus, Image Decoding Apparatus, Image Transmission System, Image Accumulation System, and Image Reproduction System

2. Inventors

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(2) Minoru ETOH
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3. Affiliation of Inventors

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(3) Multimedia Laboratories, Multimedia Signal Processing Laboratory
(4) */blank/*

4. Field of Applicability

Image encoding methods, image decoding methods, image encoding apparatus, image decoding apparatus, image transmission systems, image storing systems, and image reproduction systems

5. Object

To perform efficient coding of orthogonal transform coefficients by applying context-based adaptive variable length coding to an image encoding method where the size of blocks for orthogonal transform is variable.

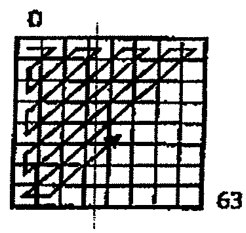
6. Summary and Constitution

- **Difference from the prior art**
- **Structural diagrams**

- Gist of claims

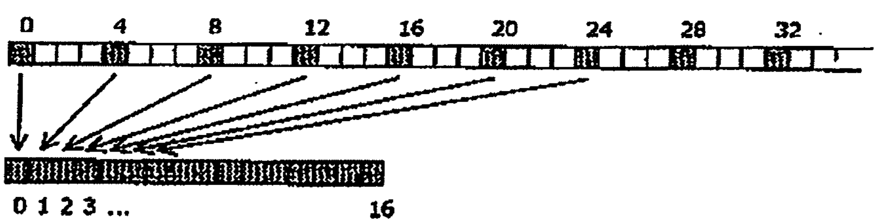
Although encoding efficiency can be greatly improved by applying context-based adaptive variable length coding to orthogonal transform coefficients, it is necessary to employ encoding tables and encoding rules when such coding is to be applied in an image encoding method where the size of blocks subjected to orthogonal transform is variable, there was thus the problem that the means became complicated. The present invention applies context-based adaptive variable length coding only to blocks of a minimum size. Blocks of a larger size are divided into coefficient strings, so that the variable length coding is applied to a plurality of coefficient strings equal in size to that of a coefficient string in a block of the minimum size.

COEFFICIENT MATRIX BEFORE READOUT

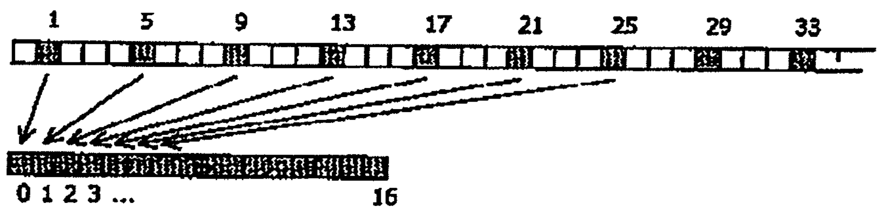


COEFFICIENT STRING AFTER READOUT

FIRST COEFFICIENT STRING



SECOND COEFFICIENT STRING



7. Advantageous Effects

In accordance with the present invention, efficient encoding of orthogonal transform coefficients can be achieved without complicating the procedure and the structure, and enabling encoding by the same procedure when applied only to blocks of a minimum size, even when context-based adaptive variable length coding is applied in cases where the size of the blocks for orthogonal transform is variable.

8. Remarks

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MSWord with adaptation for handwriting

TABLE OF NAMES OF INVENTORS

NTT DoCoMo
Docket No. 14-0422

<table>
<tr><td rowspan="10">Inventors

Representative inventors are to be listed first</td><td>Title of the Invention</td><td colspan="4">Image Encoding Method, Image Decoding Method, Image Encoding Apparatus, Image Decoding Apparatus, Image Transmission System, Image Accumulation System, and Image Reproduction System</td></tr>
<tr><td colspan="3">Inventors inside the Company</td><td colspan="2">Inventor Outside the Company</td></tr>
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</table>

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平成１４年10月8日

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記

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（３）発明者氏名表		1通

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14.10. 8
14-0422

【発明の名称】

直交変換を行うブロックのサイズを複数から選択することができる場合に、直交変換係数の効率的なエントロピー符号化を可能とする、

画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システム

【特許請求の範囲】

<符号化方法クレーム、基本クレーム>

【請求項1】

画像信号をブロックに分割して直交変換を行い、得られた直交変換係数を順に読み出した係数列とした上で、エントロピー符号化する画像符号化方法であって、

前記直交変換を行うブロックについてサイズの異なる複数のブロックを有し、その中から選択する手段を備え、

前記複数のブロックの中で、最小サイズのブロックにおける前記係数列に適応したエントロピー符号化を行うための手段を備え、

より大きなサイズのブロックが選択された場合に、そのブロックにおける係数列を、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列へ分割する手段を備え、

前記分割された係数列を、前記エントロピー符号化手段により符号化することを特徴とする画像符号化方法。

<符号化方法クレーム、係数分割方法、交互読み出し>

【請求項　】

前記係数列分割手段は、係数列を低周波領域の係数から順に読み出し、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列に、それぞれ交互に割り当てることにより、分割後の係数列を得ることを特徴とする、前記請求項1に記載の画像符号化方法。

<符号化方法クレーム、係数分割方法、周波数帯域毎>

【請求項　】

前記係数列分割手段は、係数列を低周波領域の係数から順に読み出し、最小サイズのブロックにおける係数列と同じ係数の数だけ読み出して分割後の係数列とすることを繰り返すことにより、分割後の係数列を得ることを特徴とする、前記請求項1に記載の画像符号化方法。

<復号方法クレーム、基本クレーム>

【請求項　】

画像信号をブロックに分割して直交変換を行い、得られた直交変換係数を順に読み出した係数列とした上で、エントロピー符号化する画像符号化方法による、符号化データを復号する画像復号方法であって、

前記直交変換を行うブロックについてはサイズの異なる複数のブロックを有し、その中

から選択する手段を備え、

前記複数のブロックの中で、最小サイズのブロックにおける前記係数列に適応したエントロピー符号化による符号化データの復号を行うための手段を備え、

より大きなサイズのブロックが選択された場合に、そのブロックにおける係数列を、そのブロックに包含される、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から構成する手段を備え、

前記複数の係数列を、前記復号手段により符号化データから復号することを特徴とする画像復号方法。

<復号方法クレーム、係数分割方法、交互読み出し>

【請求項　】

前記係数列構成手段は、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から、それぞれの係数列を低周波領域の係数から交互に読み出して新たな係数列に低周波領域から書き込み、これを構成後の係数列とすることを特徴とする、前記請求項１に記載の画像復号方法。

<復号方法クレーム、係数分割方法、周波数帯域毎>

【請求項　】

前記係数列構成手段は、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から、ひとつの係数列の係数をすべて読み出して新たな係数列に低周波領域から書き込むことを繰り返し、これを構成後の係数列とすることを特徴とする、前記請求項１に記載の画像符号化方法。

<装置クレーム>

【請求項　】

<システムクレーム>

【請求項　】

画像の符号化装置と復号装置とを含んで構成された画像処理システムであって、

前記符号化装置は、請求項　～　のいずれかに記載の画像符号化装置からなり、

前記復号化装置は、請求項　～　のいずれかに記載の画像復号装置からなることを特徴とする画像処理システム。

<コンピュータ符号化プログラム>

【請求項　】

画像符号化装置として用いるコンピュータに、請求項　～　のいずれかに記載の画像符号化方法の各工程を実行させるための画像符号化プログラム。

<コンピュータ復号プログラム>

【請求項　】

画像復号装置として用いるコンピュータに、請求項　～　のいずれかに記載の画像復号方法の各工程を実行させるための画像復号プログラム。

【発明の詳細な説明】

【発明の属する技術分野】

本発明は、画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システムに関するものである。

【従来の技術】

静止画像や動画像などの画像信号の伝送や蓄積再生を行うために、画像信号の符号化技術が用いられる。そのような技術として、静止画像の符号化技術としては ISO/IEC International Standard 10918（以下 JPEG と呼ぶ)、動画像の符号化技術としては ISO/IEC International Standard 14496-2（MPEG-4 Visual、以下 MPEG-4 と呼ぶ）などの国際標準化符号化方式が知られている。またより新しい符号化方式として、ITU-T と ISO/IEC との合同国際標準化が予定されている動画像符号化方式、ITU-T Recommendation H.264、ISO/IEC International Standard 14496-10（Joint Final Committee Draft of Joint Video Specification

ftp//ftp.imtc-files.org/jvt-experts/2002_07_Klagenfurt/JVT-D157.zip、以下 H.26L と呼ぶ）が知られている。これらの画像符号化方式に用いられている一般的な符号化技術については、例えば小野 文孝、渡辺 裕 共著、「国際標準画像符号化の基礎技術」、コロナ社、1998 年 3 月 20 日、を参照されたい。

画像信号では、空間的に隣接する画素間の相関が大きいことから、周波数領域へ変換すると低周波領域に情報が偏ることとなり、この偏りを利用した冗長の削減が可能となる。そこで一般的な画像符号化方式では、画像信号に直交変換を行い周波数領域における直交変換係数へと変換して信号成分を低周波領域に偏らせ、さらにこの係数値に対して量子化を行い値の小さな係数をゼロ値とする。これを低周波領域の係数から順に読み出して係数列とした上で、係数値の偏りを利用したエントロピー符号化を行い、冗長を削減した効率的な符号化を実現する。

この場合に直交変換としては、符号化効率や実装の容易さの点から、離散コサイン変換（Discrete Cosine Transform、DCT）が広く用いられている。DCT などによる直交変換は、画像信号を複数の画素から構成されるブロックに分割してこのブロックの単位で行われる。このブロックの大きさは画像信号の性質とともに符号化効率に大きく影響する。

画像信号における空間的な性質の変化が小さければ、同じような周波数領域の直交変換係数に変換される画像信号が画像上で広く分布していることから、ブロックの大きさ、すなわち直交変換の大きさを大きくすることにより、小さなブロックを用いた場合に同じ直交変換係数を繰り返し表現する必要が生じてしまうことと比較して、より冗長を削減することができるようになり符号化効率が向上する。他方で画像信号における空間的な性質の変化が大きければ、ブロックの大きさを大きくしてしまうと、その直交変換係数には様々な周波数成分が含まれて係数の偏りが小さくなることから、効率的なエントロピー符号化を行うことが困難となり、符号化効率は悪化してしまう。

このような、直交変換を行うブロックの大きさと、画像信号の性質の変化による符号化

効率の変化を利用するために、あらかじめ複数のブロックのサイズでの直交変換手段を用意しておき、それらの中から最も良い符号化効率の得られるサイズを適応的に選択して用いる技術が利用される。この技術は適応ブロックサイズ直交変換（Adaptive Block size Transforms、ABT）と呼ばれ、H.26L において採用されている。図１に H.26L における ABT にて用いられる直交変換ブロックを示す。ABT では、図１（ａ）に示す１６×１６画素のマクロブロック毎に、図１（ｂ）～（ｅ）に示す４種類の直交変換ブロックサイズの中から、最も良い符号化効率の得られるサイズを選択することができる。マクロブロックの画素値に対しては、選択されたサイズのブロックにより等分割されて直交変換が行われることとなる。このような選択を行うことにより、マクロブロックにおける画像信号の空間的な性質の変化に合わせて、直交変換を利用した冗長の削減を効率的に行うことができる。なお ABT のより具体的な詳細については、H.26L を参照されたい。

直交変換により得られた直交変換係数に対するエントロピー符号化は、直交変換係数を低周波領域の係数から順に読み出した係数列について行われる。図２（ａ）に４×４画素の直交変換ブロックにおける係数の読み出し順を示す。直交変換を行って得られる係数は左上を最も低周波の成分（すなわち直流成分）として配置されることから、左上の係数から順に読み出しを行い、図２（ｂ）に示すような１６個の係数からなる係数列を得る。このような読み出し順はジグザグスキャンと呼ばれる。

直交変換により得られた係数は互いに無相関化されており、また信号成分が低周波領域に偏ることから、これをさらに量子化した場合には、低周波領域の係数ほど非ゼロの係数値となり、また係数列中にゼロ値となる係数が数多く現れる。例えば、図２（ｃ）に示すような係数値の並びとなる。そこでこのような分布の係数列を効率よくエントロピー符号化するために、画像符号化においては一般的に、係数列を非ゼロ係数に先行するゼロ係数の連続数（ラン）および非ゼロ係数の係数値（レベル）により表現して符号化を行う。ABT による直交変換係数のエントロピー符号化についても、このようなランとレベルによる符号化が用いられている。

他方で、このようなエントロピー符号化を行う際により効率を高めるために、コンテキスト適応可変長符号（Context-based Adaptive Variable Length Code、CAVLC）と呼ばれる技術が H.26L において採用され、ABT を用いない場合の直交変換、すなわち直交変換が常に４×４画素の直交変換ブロックの単位にて行われる場合において用いられている。

H.26L における CAVLC では、４×４画素の直交変換ブロックから得られる係数列に含まれる係数が最大でも１６個であり、ランの大きさはこの最大数により制限されること、またレベルの大きさは低周波領域のものほど大きな値となりやすいこと、を利用して、可変長符号化に用いる符号化テーブルをそれぞれの条件毎に最適化したものとして多数用意し、これを順次切り替えて適用することにより、符号化効率を向上させている。

例えば各ランの符号化を順に行っていく場合、はじめのランにおいては０から１４（H.26L におけるランの定義により、ランの最大数は全係数数より２だけ少ない１４となる）までの様々な値を取り得るが、順にランを符号化していった後の終わりの方のランにおいては、係数列に含まれる係数の数に上限があることから、限られたランの値しか取り得ない。したがって、図３に示すように、はじめの方のランにおいては符号化テーブルの

要素数がもっとも多い右側の符号化テーブルを用い、終わりの方のランとなるに従い、符号化テーブルの要素数を小さくした左側の符号化テーブルを適用することにより、より少ないビット数の符号を割り当てて効率的にエントロピー符号化を行うことができる。CAVLCにおいては、このようにブロックに含まれる係数の最大数などの条件を利用して、符号化すべき値が取り得る範囲に制限を加えることにより効率的な符号化を実現している。なおCAVLCのより具体的な詳細については、H.26Lを参照されたい。

【発明が解決しようとする課題】

上述のようなCAVLCをABTに適用することにより、ABTの係数列においてもより効率的なエントロピー符号化を実現することが期待できる。

しかしながら、CAVLCはブロックに含まれる係数の最大数に基づきながら、可変長符号化に用いる符号化テーブルをそれぞれの条件毎に最適化し、これを切り替えながら符号化に用いることにより符号化効率を向上させている。

ABTを用いた場合には、サイズの異なるブロック毎に含まれる係数数が異なり、図１（ｂ）の８×８ブロックの場合には６４個、図１（ｃ）、（ｄ）の８×４、４×８ブロックの場合には３２個、図１（ｅ）の４×４ブロックの場合には１６個となる。このため、CAVLCを適用するためにはそれぞれの場合において起こり得る膨大な条件を考慮する必要が生じる。

例えば図３に示すランの符号化テーブルのように、係数列に含まれる係数の数の上限に応じて符号化テーブルを設定しようとした場合、６４個の係数数となる８×８ブロックの場合には、要素数２の符号化テーブルから、要素数６２個の符号化テーブルまでの膨大な数の符号化テーブルを用意する必要が生じる。これと同様に、３２個の係数数となる８×４、４×８ブロックにおいても要素数２から要素数３０までの符号化テーブルを用意することとなってしまう。

このように、ABTのようにサイズの異なる直交変換ブロックを選択して用いる直交変換において、CAVLCのように係数の特性に最適化したエントロピー符号化を適用しようとした場合には、用意すべき符号化テーブルの数が膨大になってしまい、符号化テーブルの保持に必要なメモリ量が膨大になってしまうという問題があった。またそれぞれのサイズのブロックについて用いられる符号化テーブル、ならびにその選択手順がそれぞれ異なることとなるため、エントロピー符号化における手順が複雑なものとなり、実現手段や装置構成が複雑になってしまうという問題があった。

本発明は、以上の問題点を解決するためになされたものであり、可変サイズの直交変換における効率的なエントロピー符号化を可能とする、画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システムを提供することを目的とする。

【課題を解決するための手段】

このような目的を達成するために、本発明に係る画像符号化方法は、

<符号化方法クレーム、基本クレーム>

画像信号をブロックに分割して直交変換を行い、得られた直交変換係数を順に読み出し

た係数列とした上で、エントロピー符号化する画像符号化方法であって、
前記直交変換を行うブロックについてサイズの異なる複数のブロックを有し、その中から選択する手段を備え、
前記複数のブロックの中で、最小サイズのブロックにおける前記係数列に適応したエントロピー符号化を行うための手段を備え、
より大きなサイズのブロックが選択された場合に、そのブロックにおける係数列を、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列へ分割する手段を備え、
前記分割された係数列を、前記エントロピー符号化手段により符号化することを特徴とする。
このように、本発明に係る画像符号化方法においては、大きなサイズのブロックが選択されて直交変換が行われる場合に、そのブロックにおける係数列を分割してからエントロピー符号化を行うこととしている。これにより、係数列のエントロピー符号化において、最小サイズのブロックにおける係数列に適応したエントロピー符号化を用いることができ、エントロピー符号化の手順を複雑化させることなく、直交変換係数の効率的なエントロピー符号化を実現することができる。
<符号化方法クレーム、係数分割方法、交互読み出し>
また、係数列分割手段については、係数列を低周波領域の係数から順に読み出し、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列に、それぞれ交互に割り当てることにより、分割後の係数列を得ることを特徴としてもよい。
<符号化方法クレーム、係数分割方法、周波数帯域毎>
あるいはまた、係数列分割手段については、係数列を低周波領域の係数から順に読み出し、最小サイズのブロックにおける係数列と同じ係数の数だけ読み出し、これを分割後の係数列とすることを繰り返すことにより、分割後の係数列を得ることを特徴としてもよい。
本発明に係る画像復号方法は、
<復号方法クレーム、基本クレーム>
画像信号をブロックに分割して直交変換を行い、得られた直交変換係数を順に読み出した係数列とした上で、エントロピー符号化する画像符号化方法による、符号化データを復号する画像復号方法であって、
前記直交変換を行うブロックについてはサイズの異なる複数のブロックを有し、その中から選択する手段を備え、
前記複数のブロックの中で、最小サイズのブロックにおける前記係数列に適応したエントロピー符号化による符号化データの復号を行うための手段を備え、
より大きなサイズのブロックが選択された場合に、そのブロックにおける係数列を、そのブロックに包含される、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から構成する手段を備え、
前記複数の係数列を、前記復号手段により符号化データから復号することを特徴とする。
このように、本発明に係る画像復号方法においては、大きなサイズのブロックが選択されて直交変換の行われた符号化データを復号する場合に、そのブロックにおける係数列を、

そのブロックに包含されるブロックの係数列から構成することとしている。これにより、最小サイズのブロックにおける係数列に適応したエントロピー符号化を用いた符号化データから係数列を復号することができ、エントロピー符号化の復号の手順を複雑化させることなく、直交変換係数の効率的なエントロピー符号化を実現することができる。

<復号方法クレーム、係数分割方法、交互読み出し>

また、係数列構成手段については、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から、それぞれの係数列を低周波領域の係数から交互に読み出して新たな係数列に順に書き込み、これを構成後の係数列とすることを特徴としてもよい。

<復号方法クレーム、係数分割方法、周波数帯域毎>

あるいはまた、係数列構成手段は、最小サイズのブロックにおける係数列と同じ係数の数からなる複数の係数列から、ひとつの係数列の係数を低周波領域の係数からすべて読み出して新たな係数列に書き込むことを繰り返し、これを構成後の係数列とすることを特徴としてもよい。

【発明の実施の形態】

<第一の実施形態>

以下、図面とともに本発明による画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システムの好適な実施形態について詳細に説明する。

以下の説明における符号化および復号においては、H.26L をもとにして実現することとして説明を行い、画像符号化における動作について特に触れていない部分については、H.26L の動作に準じるものとする。ただし本発明は H.26L に限定されるものではない。

本発明の実施形態について説明する。本実施形態による符号化においては、H.26L における ABT のそれぞれのサイズのブロックの直交変換係数について、これから得られる係数列を、４×４ブロックの係数列における係数の数と同じ数からなる複数の係数列に分割することにより、４×４ブロックに適応させて定義された H.26L の CAVLC によりエントロピー符号化することができるようにしている。

符号化においてはまず、ひとつのマクロブロックに対して H.26L における ABT が適用されて、図１（ｂ）～（ｅ）に示したブロックの中から最も良い符号化効率の得られるサイズが選択され、そのブロックの単位にて直交変換がなされているものとする。

また直交変換係数のエントロピー符号化として、H.26L における CAVLC が用いられるものとする。すなわち、図１（ｅ）に示した４×４ブロックについての直交変換係数の符号化に適応させた可変長符号化のみが定義されているものとする。

例えばここで、図１（ｂ）の８×８ブロックが選択されたものとする。この８×８ブロックについて、以下のような直交変換係数の読み出し操作を行う。まず、８×８ブロックにおける６４個の係数を、図４（ａ）に示すようにジグザグスキャンにより読み出し、図４（ｂ）に示すような係数列を得る。

次にこの係数列を、４×４ブロックの係数列における係数の数と同じ、１６個の係数からなる４つの係数列に分割するものとする。ここで、もとの係数列を低周波領域の係数か

ら読み出しながら、４つの係数列にそれぞれ交互に割り当てることにより、分割後の係数列を得る。図４（ｃ）、（ｄ）にこの読み出し操作を示す。低周波領域の係数から各係数列へと交互に割り当てられることから、第１の分割後係数列には、もとの係数列における０番目、４番目、８番目、１２番目、と続く係数がそれぞれ読み出され割り当てられることとなり、第２の分割後係数列には１番目、５番目、９番目、１３番目、と続く係数がそれぞれ読み出され割り当てられることとなる。図４では第３、第４の分割後係数列については省略している。

同様にして、図１（ｃ）または（ｄ）の８×４ブロックまたは４×８ブロックが選択された場合には、３２個の係数を、１６個の係数からなる２つの係数列に分割するものとする。分割後の係数列を得るための読み出し方も、交互に割り当てる係数列の数が４から２になることを除いて８×８ブロックの場合と同様であることとし、もとの係数列を低周波領域の係数から読み出していき、２つの係数列に交互に割り当てていくこととする。

このようにして得られた係数列は、ABT が用いられていない場合における CAVLC の符号化と全く同じ手順によりエントロピー符号化され、順に ABT ブロックにおける直交変換係数の符号化データとして出力されるものとする。

このとき、H.26L の CAVLC では、隣接する４×４ブロックにおける非ゼロ係数数に基づいて用いる符号化テーブルを切り替える、空間コンテキストが利用される。このため、４×４ブロックよりも大きな ABT ブロックについて、分割後の係数列の ABT ブロック内での配置を定義する。この定義を図５に示す。例えば図５（ａ）に示す８×８ブロックでは、図４（ｃ）で説明した第１の分割後係数列は「１」の位置に、また図４（ｄ）で説明した第２の分割後係数列は「２」の位置に、それぞれ配置されているものとして扱う。この配置の定義を用いて、ABT ブロック内の分割後係数列についての空間コンテキスト、あるいは ABT ブロックに隣接する４×４ブロックについての空間コンテキストは、H.26L における CAVLC での手法とまったく変更なく扱われるものとする。

復号においては、符号化における手順と逆の手順により、もとの直交変換行列を得ることができる。

ひとつのマクロブロックに H.26L における ABT が適用されて、図１（ｂ）～（ｅ）に示したブロックの中からサイズが指示され、このマクロブロックに対する符号化データでは、その ABT ブロックの単位にて行われた直交変換がなされているものとする。

このとき符号化データには、分割後係数列を CAVLC によりエントロピー符号化した符号化データが、ABT ブロックにおける直交変換係数の符号化データとして順に含まれていることとなる。したがってこれを順次、CAVLC の手順に従って復号し、￥分割後係数列を得る。

これらの分割後係数列は、図４に示した読み出し方により分割された係数列であるから、逆に分割後係数列の係数をもとの係数列に書き込み、さらに得られた係数列を直交変換係数ブロックに書き込むことにより、もとの直交変換係数ブロックを得ることができる。以降は、H.26L における ABT が適用された場合の復号の手順と同じである。

なお本実施形態においては、直交変換係数の読み出しはジグザグスキャンによるものとしたが、本発明を適用する際の係数の読み出し方法は、ジグザグスキャンに限られるものではない。例えば H.26L の ABT において定義されている、インターレース画像におけるフ

ィールド符号化を行うための、フィールドスキャンが適用される場合に本発明を適用することとしてもよい。この場合でも、本実施形態における係数列の分割手法はそのまま適用可能である。

また本実施形態においては、分割後の係数列を得るための読み出し方を、図４に示したような交互の読み出しによるものとして示したが、これとは異なる読み出し方を行って分割後の係数列を得ることとしてもよい。例えば図６（ｃ）、（ｄ）に示すように、もとの係数列を低周波領域の係数から１６個ずつ連続して読み出していき、それぞれを分割後の係数列ひとつに割り当てていくこととしてもよい。

また本実施形態においては、符号化における直交変換係数の読み出しは、直交変換ブロックから係数列を得るための第一の読み出しの後に、分割後の複数の係数列を得るための第二の読み出しを行うこととしている。また復号における直交変換係数の書き込みは、構成後の係数列を得るための第一の書き込みの後に、直交変換ブロックを得るための第二の書き込みが行われることとしている。しかしながら本発明による係数の読み出し、書き込みはこれらに限られるものではなく、所望の配置による係数列が得られるような、さまざまな読み出し、書き込み方法をとることができる。例えば、直交変換ブロックからの第一の係数読み出しにおいて、直ちに分割後の複数の係数列が得られるように読み出しを行ってもよい。また分割後係数列からの書き込みにおいても、第一の係数書き込みにおいて直ちに直交変換ブロックが得られるように行ってもよい。

また本実施形態においては、分割後の係数列を図５のように配置し、H.26L における CAVLC での隣接する４×４ブロックからの空間コンテキストが、まったく変更なく扱われるものとしたが、このとき、４×４ブロックより大きな ABT ブロックの係数列から分割された係数列は、もともと４×４ブロックであった場合の係数列とは性質が異なると考えて、空間コンテキストとして用いる数値に重み付けを行うこととしてもよい。具体的には、隣接するブロックからの空間コンテキストとして非ゼロ係数数が用いられるが、４×４ブロックよりも大きな ABT ブロックから得られた分割後係数列についての非ゼロ係数数は、空間コンテキストとして用いられる際に常に定数を加算もしくは乗算した値が用いられることとしてもよい。あるいはまた、図６に示したように低周波領域から連続して読み出すことにより分割後の係数列が得られている場合には、低周波領域から読み出されたものと高周波領域から読み出されたものとで異なる定数を加算もしくは乗算されることとしてもよい。

本実施形態の説明は H.26L をもとにして実現したものとして説明し、また H.26L における ABT、CAVLC に基づいて説明したが、本発明を適用することのできる画像符号化方式は H.26L に限定されるものではなく、直交変換を行うブロックのサイズを複数から選択することができ、直交変換係数に適応させたエントロピー符号化が用いられる様々な画像符号化方式に適用することが可能である。

【発明の効果】

本発明による、画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システムは、以上詳細に説明したように、次のような効果を得る。すなわち、直交変換を行うブロックのサイズを複数から選択する

ことができる場合に、得られた直交変換係数からなる係数列を、最小サイズのブロックにおける係数列と同じ大きさの複数の係数列に分割し、これに対して最小サイズのブロックにおける係数列に適応したエントロピー符号化を行うことにより、エントロピー符号化における符号化テーブルの数を増大させることなく、また符号化テーブルならびにその選択手順を複雑なものとすることなく、効率的なエントロピー符号化を行うことが可能となる。

【図面の簡単な説明】

【図１】

H.26L の適応ブロックサイズ直交変換（Adaptive Block size Transforms、ABT）において用いられる直交変換ブロックについて示す図である。

【図２】

４×４ブロックにおける係数の読み出し方法と、読み出し後の係数列の一例について示す図である。

【図３】

H.26L のコンテキスト適応可変長符号（Context-based Adaptive Variable Length Code、CAVLC）において用いられる、ランの符号化テーブルについて示す図である。

【図４】

本発明による直交変換係数の読み出しおよび分割を、８×８ブロックについて行った例について示す図である。

【図５】

本発明による分割後の係数列の、もとのブロック内における配置の定義について示す図である。

【図６】

本発明による直交変換係数の読み出しおよび分割の、もうひとつの方法を、８×８ブロックについて行った例について示す図である。

【書類名】　要約書

【要約】

【課題】

【解決手段】

14-0422

発明の概要

様式－1(4/4)
MSWord及び手書き対応

1．発明の名称	画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システム	
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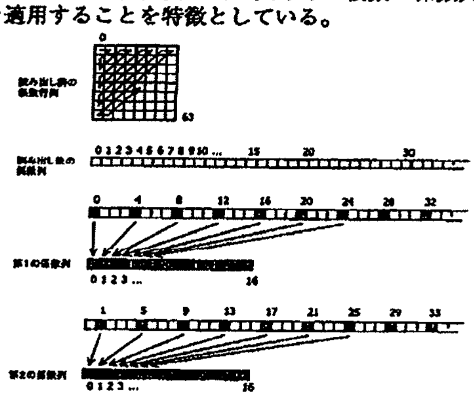
	③ 加藤　禎篤	④
3．発明者所属	① マルチメディア研究所 マルチメディア信号処理研究室	② マルチメディア研究所 マルチメディア信号処理研究室
	③ マルチメディア研究所 マルチメディア信号処理研究室	④
4．適応分野	画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび動画像再生システム	
5．目的	直交変換を行うブロックのサイズが可変である画像符号化方法にて、コンテキスト適応可変長符号化を適用し、直交変換係数を効率的に符号化する。	
6．概要及び構成 ・従来技術との差異 ・構成図 ・請求範囲の要点	直交変換係数に対してコンテキスト適応可変長符号化を適用することにより大きな符号化効率改善が得られるが、直交変換を行うブロックのサイズが可変である画像符号化方法においてこれを適用しようとする場合、それぞれの場合における符号化テーブル、符号化ルールを用いる必要があり、手段が複雑になってしまうという問題があった。本発明では、コンテキスト適応可変長符号化を、最小のサイズのブロックについてのみ適用する。それより大きなサイズのブロックについては、係数列を分割して最小のサイズのブロックにおける係数列と同じ大きさの複数の係数列とし、前記可変長符号化を適用することを特徴としている。  	
7．効果	本発明によれば、直交変換を行うブロックのサイズが可変である場合においてコンテキスト適応可変長符号化を適用した場合でも、最小のサイズのブロックについてのみ適用した場合と同じ手順にて符号化を行うことができ、手順や構成を複雑にしてしまうことなく、効率的な直交変換係数の符号化を実現することができる。	
8．備考		

様式－1 (2/4)
MSWord 及び手書き対応

発明者氏名表

NTT DoCoMo
整理番号 14-0422

発明者記入欄

代表発明者は先頭欄に

発明の名称	画像符号化方法、画像復号方法、画像符号化装置、画像復号装置、画像伝送システム、画像蓄積システムおよび画像再生システム			
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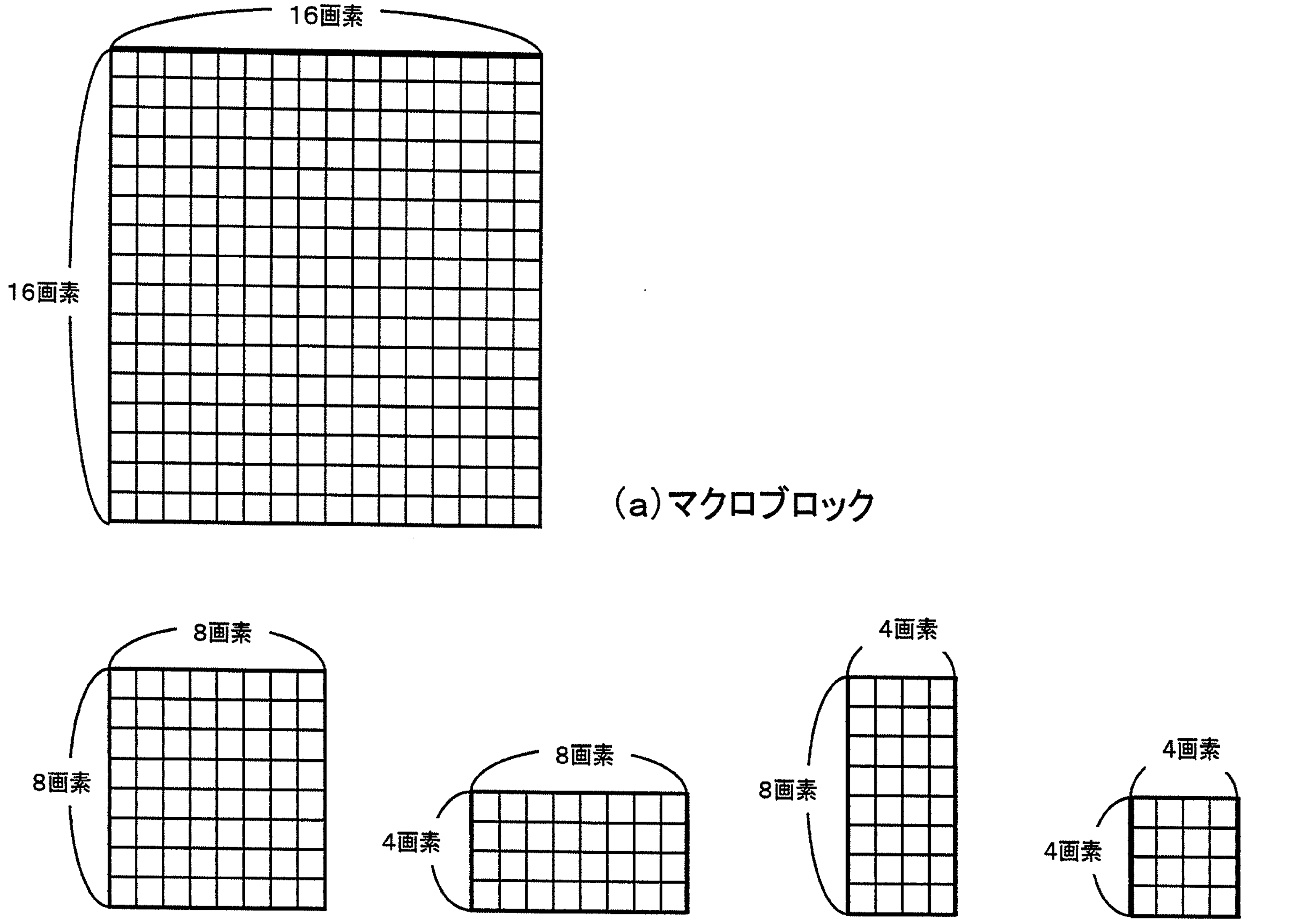
代表発明者	電話 Fax	[redacted] [redacted]	提出年月日	平成 14 年 10 月 7 日

[redacted]

Exhibit H



(a)マクロブロック

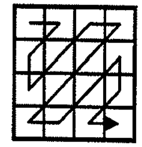
(b)直交変換
ブロック8×8

(c)直交変換
ブロック8×4

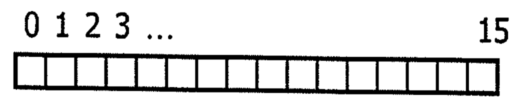
(d)直交変換
ブロック4×8

(e)直交変換
ブロック4×4

【図1】



（a）直交変換係数の読み出し



（b）読み出し後の係数列

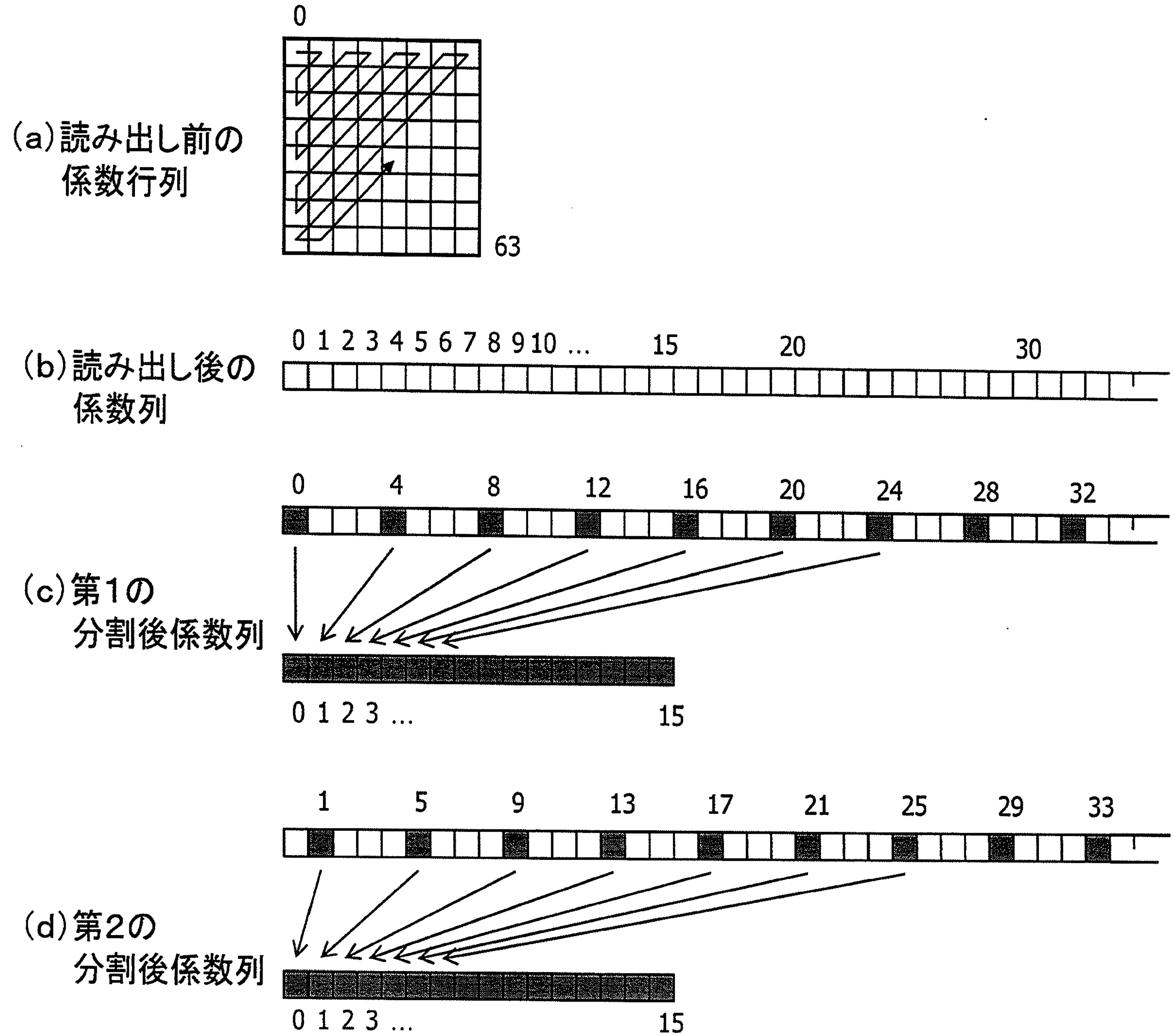
番号	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
係数値	16	0	0	8	4	0	1	0	2	1	0	0	1	0	0	0

（c）読み出し後の係数列の例

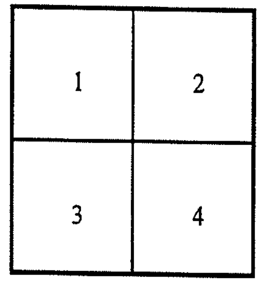
【図2】

ラン	1	2	3	4	5	6	>6
0	1	1	11	11	11	11	111
1	0	01	10	10	10	000	110
2	-	00	01	01	011	001	101
3	-	-	00	001	010	011	100
4	-	-	-	000	001	010	011
5	-	-	-	-	000	101	010
6	-	-	-	-	-	100	001
7	-	-	-	-	-	-	0001
8		-	-	-	-	-	00001
9	-	-	-	-	-	-	000001
10	-	-	-	-	-	-	0000001
11	-	-	-	-	-	-	00000001
12	-	-	-	-	-	-	000000001
13	-	-	-	-	-	-	0000000001
14	-	-	-	-	-	-	00000000001

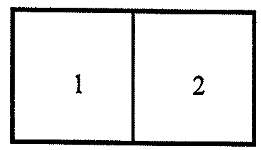
【図3】


(a)読み出し前の係数行列
0
63
(b)読み出し後の係数列
0 1 2 3 4 5 6 7 8 9 10 … 15 20 30
(c)第1の分割後係数列
0 4 8 12 16 20 24 28 32
0 1 2 3 … 15
(d)第2の分割後係数列
1 5 9 13 17 21 25 29 33
0 1 2 3 … 15

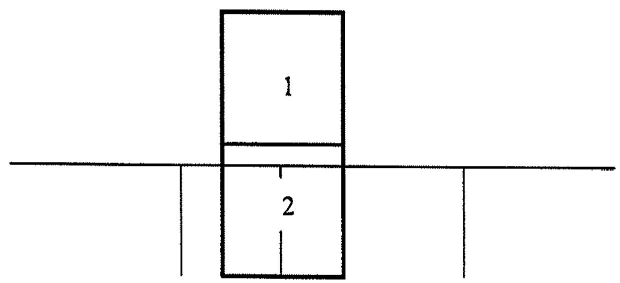
【図4】



(a)８×８ブロックにおける分割後係数列の配置の定義

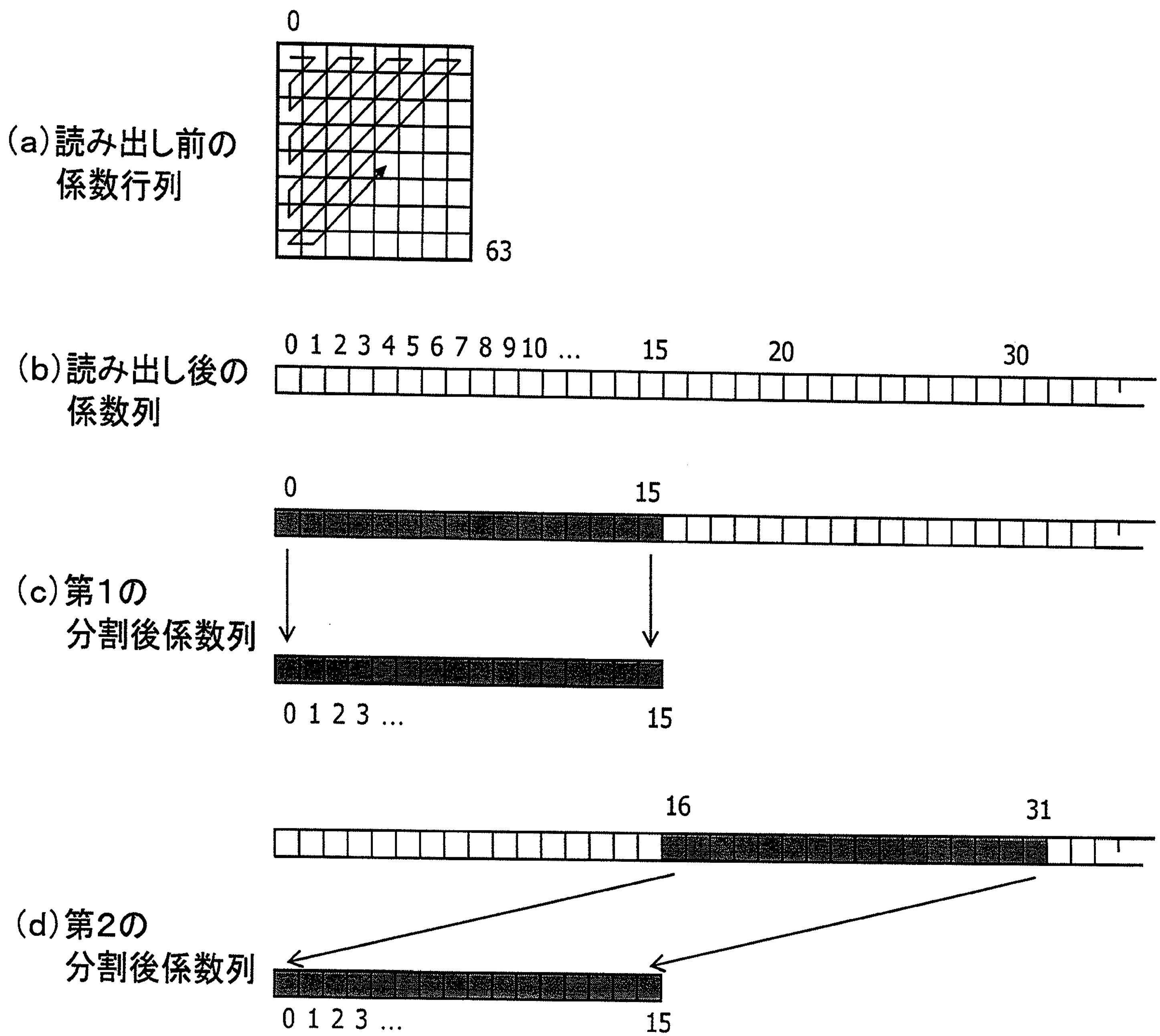


(b)８×４ブロックにおける分割後係数列の配置の定義



(c)４×８ブロックにおける分割後係数列の配置の定義

【図5】


(a)読み出し前の係数行列
0
63
(b)読み出し後の係数列
0 1 2 3 4 5 6 7 8 9 10 …
15
20
30
(c)第1の分割後係数列
0
15
0 1 2 3 …
15
(d)第2の分割後係数列
16
31
0 1 2 3 …
15

【図6】